LIGHTING DATA

INDEX 2 403.-9.

BULLETIN LD-107B

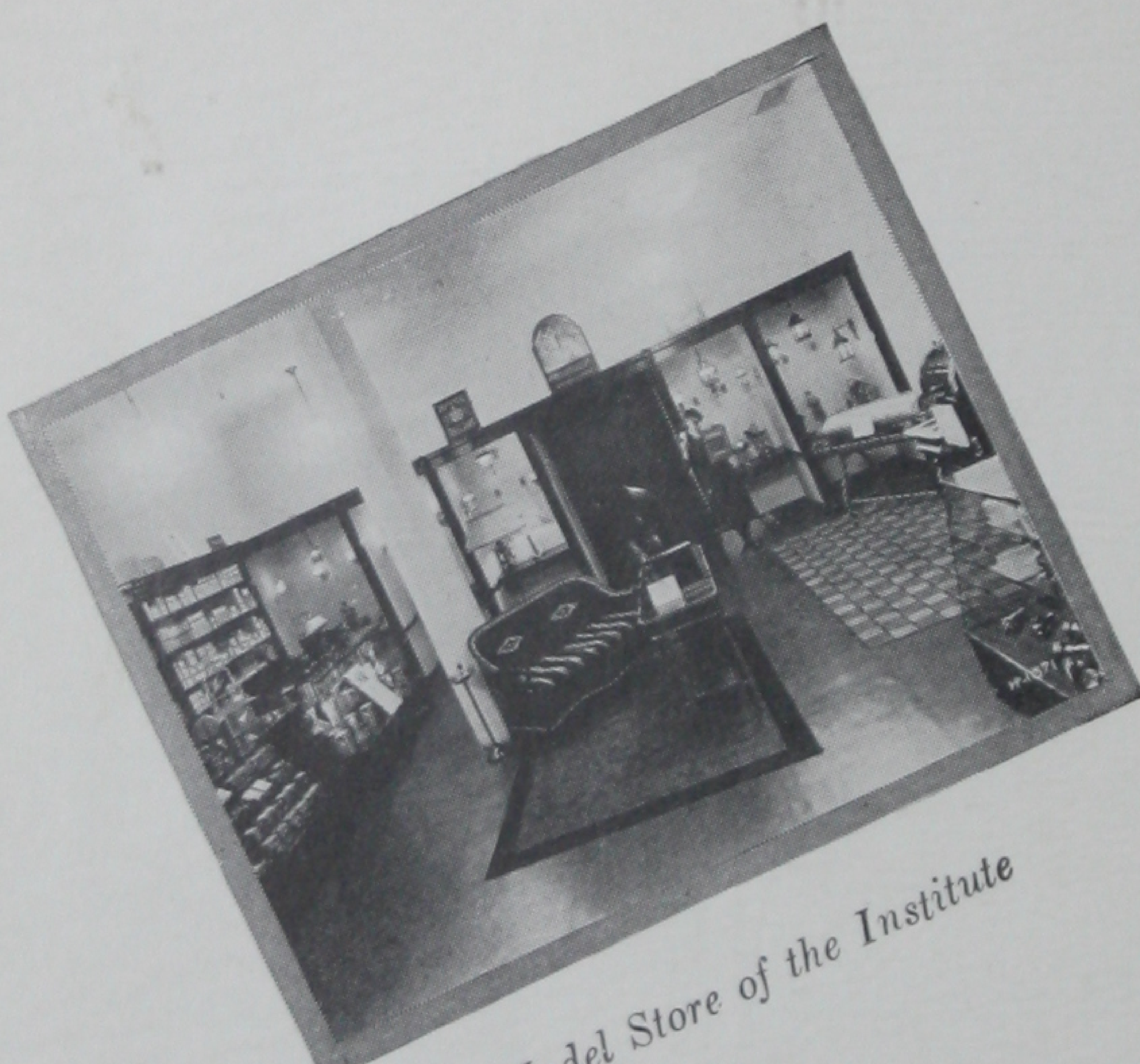
THE MAZDA LAMP IN PROJECTION SERVICE

lamps

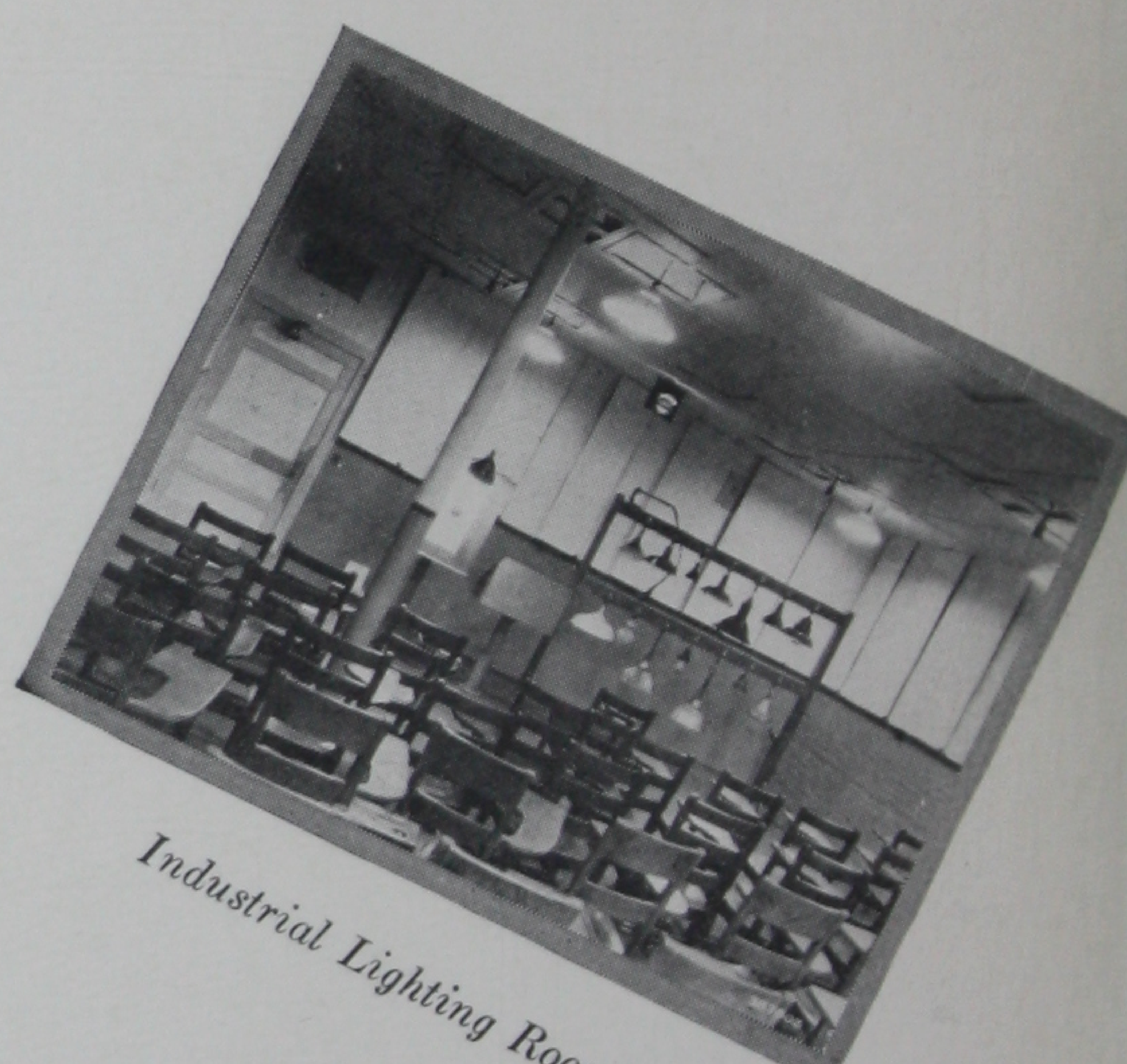
GENERAL · SALES · OFFICE · HARRISON · N · J ·

EDISON LAMP WORKS
OF GENERAL ELECTRIC COMPANY.

Where Visitors to the Institute Are Received



Model Store of the Institute

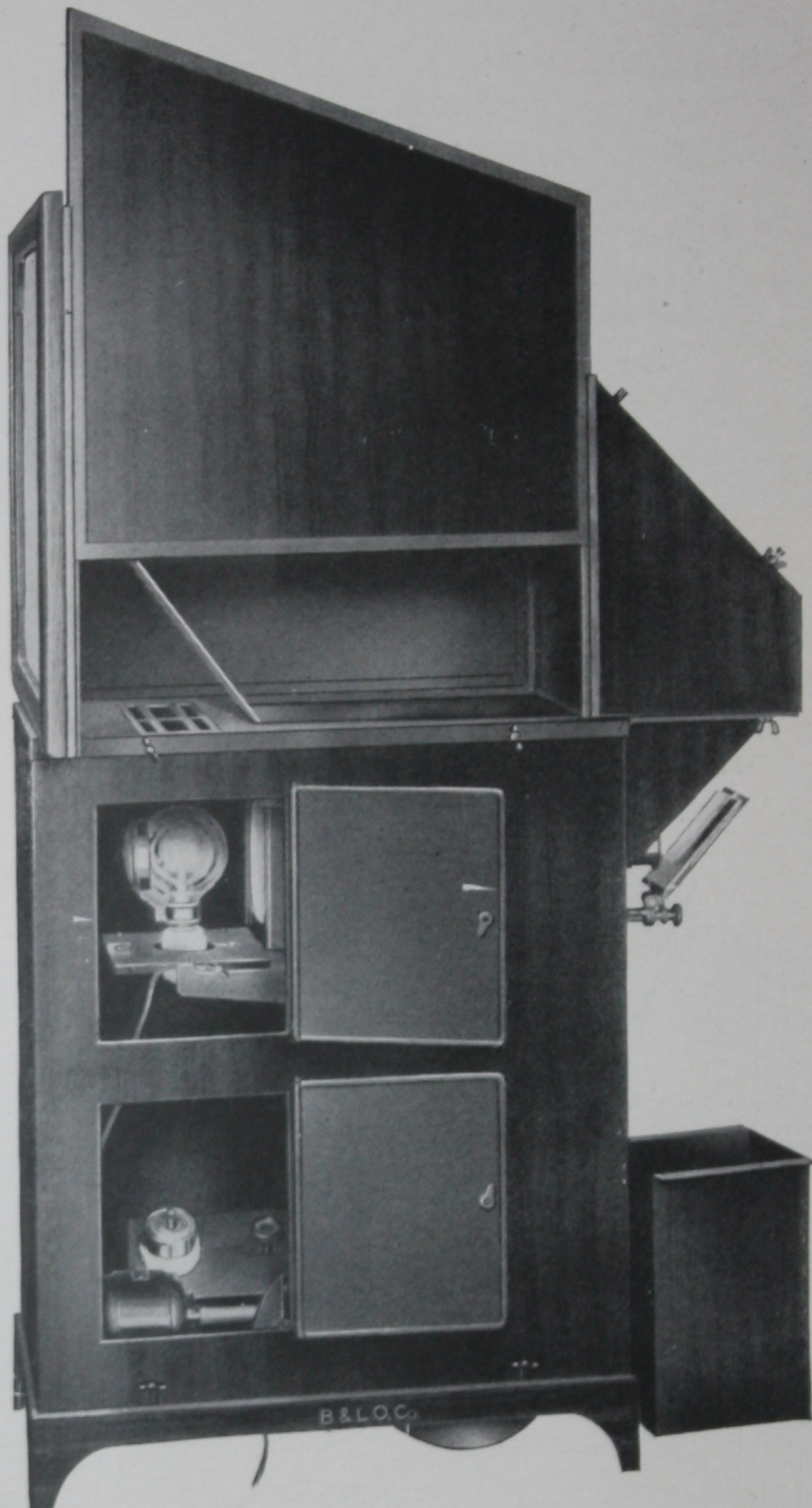


Industrial Lighting Room

At the Edison Lighting Institute, dedicated to the public for the advancement of the art and science of illumination in its many and varied applications, are portrayed most dramatically hundreds of uses of light.

The MAZDA Lamp in Projection Service

Information Compiled by
L. C. PORTER AND G. F. PRIDEAUX
Engineering Department



Stereopticons find service in the advertising field. The inherent attracting power of a continually changing display is utilized in this automatic projector, in which each of a series of slides, carried on a belt, is shown in turn for a period of 9 to 11 seconds. When the last slide is reached, the series is repeated.

Synopsis **Page**

NOTE: The information in this publication supersedes that contained in the following bulletins:

LD-107A ***The Edison MAZDA Lamp for Motion Picture Projection***
LD-116 ***The Edison MAZDA Lamp for Stereopticon Service***
LD-138 ***Fundamentals of Projection***

which should be removed from the file cases, and this issue substituted.

For information regarding MAZDA lamps and lighting questions, refer to the nearest sales office, as listed on the last page of this bulletin.

To insure receipt of bulletins, notify the Department of Publicity, Edison Lamp Works of General Electric Company, Harrison, N. J., of any change of address.

The MAZDA Lamp in Projection Service

Information Compiled by L. C. Porter and G. F. Prideaux,
Engineering Department

Introduction

Our modern methods of living and the rapidly increasing volume of things we have to know necessitate speeding up methods of conveying knowledge and information. Leading educators are coming to realize that the eye is the quickest medium we have to accomplish that end. There is, therefore, a rapidly increasing use of pictures, both still and in motion, in our modern educational institutions, as well as in the fields of entertainment and research.

With the increased use of light for projection purposes, therefore, naturally come great improvements in the equipment and methods of utilization. It is the purpose of this bulletin to outline the fundamental principles of optical projection and describe briefly the more common classes of projectors, pointing out the things essential for obtaining the best results with such apparatus.

Perhaps the earliest form of light projection was the reflection of a ray of sunlight from a polished surface. In fact, there are records of a beam of sunlight being reflected into a projector in a darkened room to show "magic lantern pictures," as they were then called.

Signalling by means of reflected sunlight is also very old. Unfortunately, the sun does not always shine at convenient times, and artificial light sources must be used. Lacking the enormous distance between ourselves and the sun to give parallel rays, we must use light sources of very small dimensions in order to get the light into a concentrated beam so as to project it to a distance.

The carbon arc lamp, which came into existence about 1800, offered the first light source sufficiently powerful and at the same time of high enough concentration to be practical for projection service. Small pieces of lime raised to white heat by oxy-acetylene flames were also used to some extent. With the almost universal availability of electric current, the "lime light" has nearly gone out of existence.

Arc lamps are, of course, improved and widely used for not only picture projection but also searchlight and signal purposes. In fact, even today the high intensity arc is used exclusively where

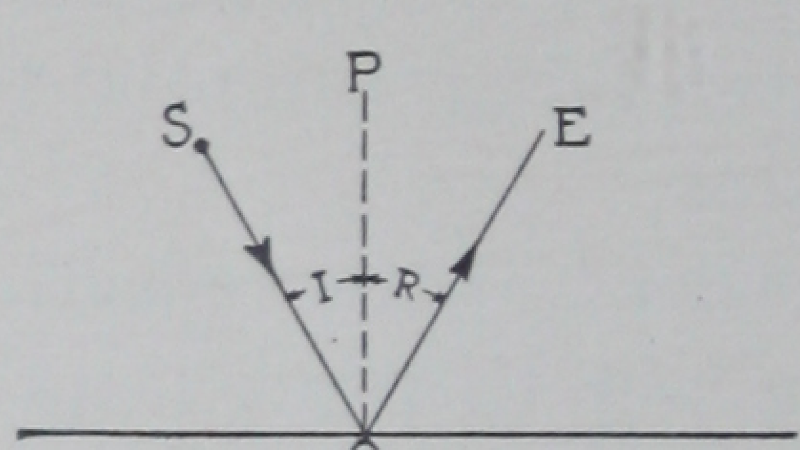
the extreme limit of range is required of a searchlight, and for a very large motion picture, or an exceptionally long throw.

The introduction of the incandescent lamp in 1879 and its rapid development through the important steps of carbon filament, squirted tungsten filament, drawn wire tungsten filament, making possible high concentration of the light source, then gas-filled lamps with their increased efficiency, have made available an ideal source for most projection work.

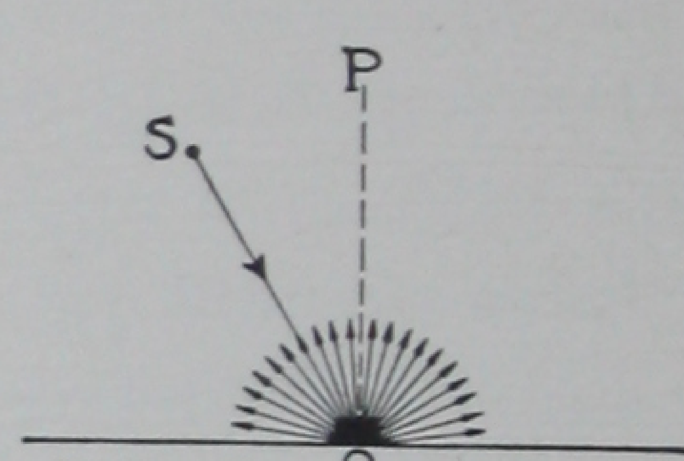
The MAZDA lamp is a clean, powerful, concentrated light source, available at the simple turn of a switch. There are no fumes given off by it, and its light is steady and of a color value to which the eye is most sensitive. MAZDA lamps have, therefore, become the almost universal light sources for projection work.

Fundamental Optics

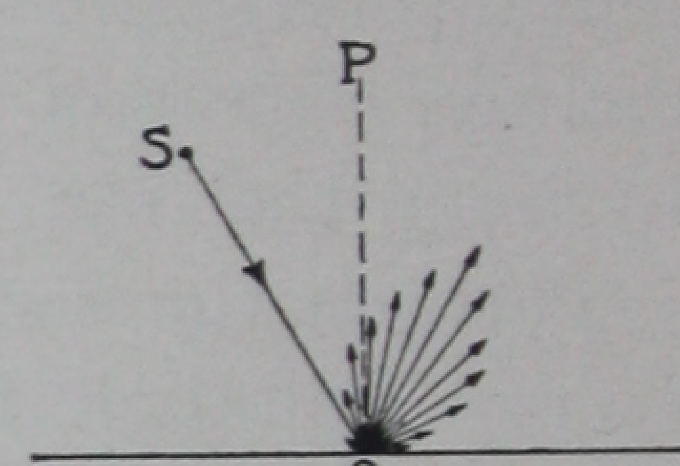
Perhaps it will be worth while to consider briefly some of the fundamental optics involved in projection work. First, of course, we must create the light—that is the function of the MAZDA lamp.



Mirror
REGULAR REFLECTION
FIG. 1



Reflecting Surface
IRREGULAR OR DIFFUSE REFLECTION
FIG. 2



Reflecting Surface
SEMI-REGULAR REFLECTION
FIG. 3

Having the light available, we now have to collect as much of it as practical and direct it to points where it will be most useful. There are two methods of directing light. One is by reflection, and the other by refraction. Reflection is of two general types, that is, specular and diffuse. When a ray of light strikes a highly polished surface, it is reflected as a ray at an angle with a normal to the reflecting surface which is equal to the angle between the normal and the incident ray. Fig. 1 illustrates this condition.

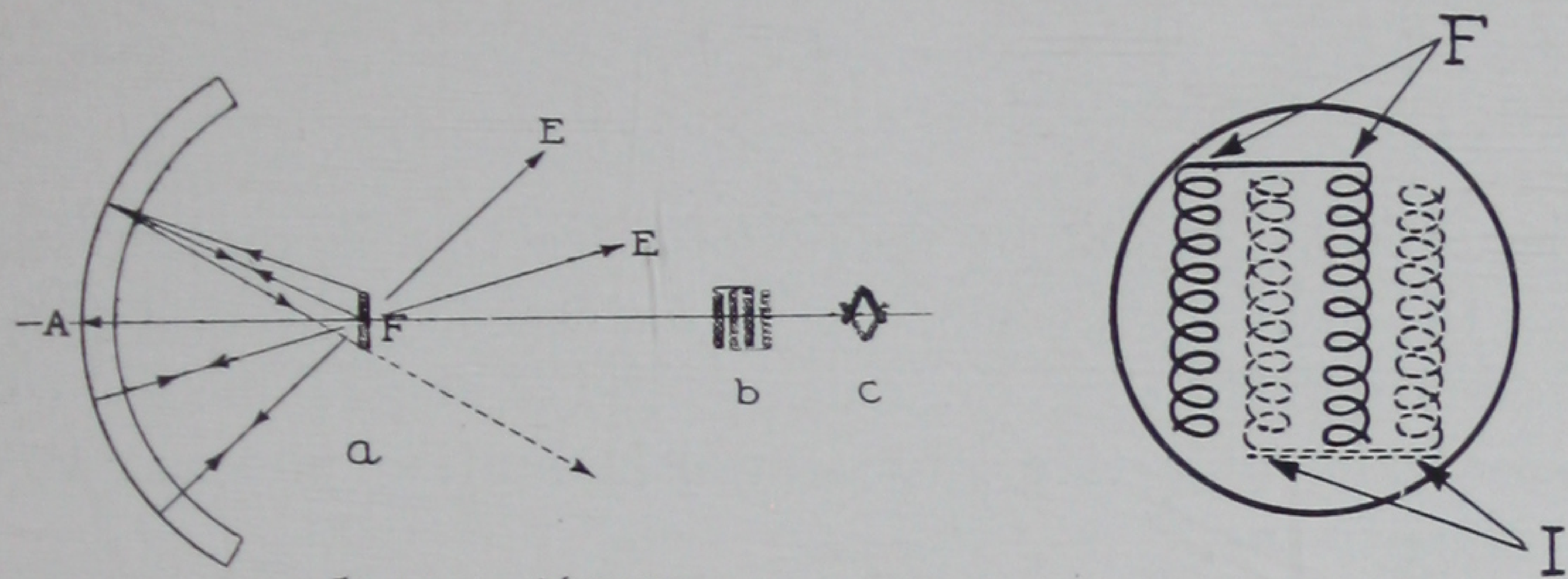
The other form of reflection is known as diffuse reflection. This occurs when a ray of light strikes an unpolished or rough diffusing surface and is broken up into many separate rays, reflected in all directions. (Fig. 2.)

There are, of course, many variations between these two extremes. Partially diffuse reflection is used in scientifically prepared motion picture screens so as to cause the picture to appear of maxi-

mum brilliancy in the directions from which the audience views it. (Fig. 3.)

Specular reflection is utilized in connection with the spherical mirrors used in back of the lamps of motion picture projectors and stereopticons.

The most common form of mirror is the ordinary flat mirror or "looking glass." Such a mirror is of little or no value in projection work. If, however, the mirror is made as a section of a sphere it may be of great value. This is because incandescent lamps give off their light practically equally in all directions. The condenser of a projector will pick up the light emanating toward it, but by itself will not utilize the light emitted to the rear. If a spherical mirror is placed behind the source it will intercept this backward light and

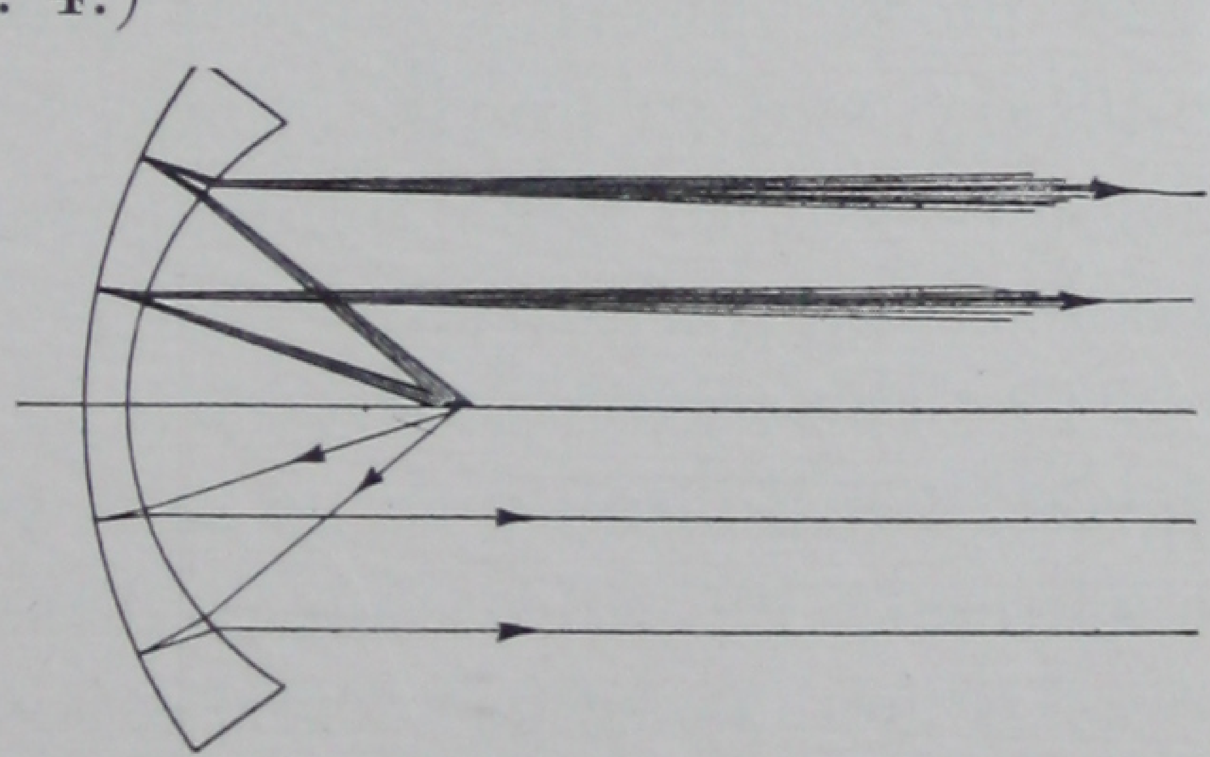


SPHERICAL MIRROR

FIG. 4. By means of the spherical mirror, the image of the filament is reflected between the coils of the actual filament, giving the effect of a nearly solid light source. This is shown at *b* at the left, and at the right is an enlarged view of this effect, *F* being the filament and *I* the inverted image.

reflect it back into the source itself, filling up the spaces between different filament coils and the turns of individual coils, thus creating in effect a solid light source. (Fig. 4.)

When adjusted correctly, spherical mirrors increase the screen illumination of stereopticon and motion picture projectors as much as 40%.



MANGIN MIRROR
FIG. 5

The most common form of the parabolic mirror is the highly polished metal reflector of the common automobile headlight. Other forms are the big glass mirrors that are ground and polished to very great accuracy for use in high-power searchlights. These mirrors deviate somewhat from the true parabola so

as to compensate for the refraction of the light as it passes twice through the glass, and are called Mangin mirrors. (Fig. 5.)

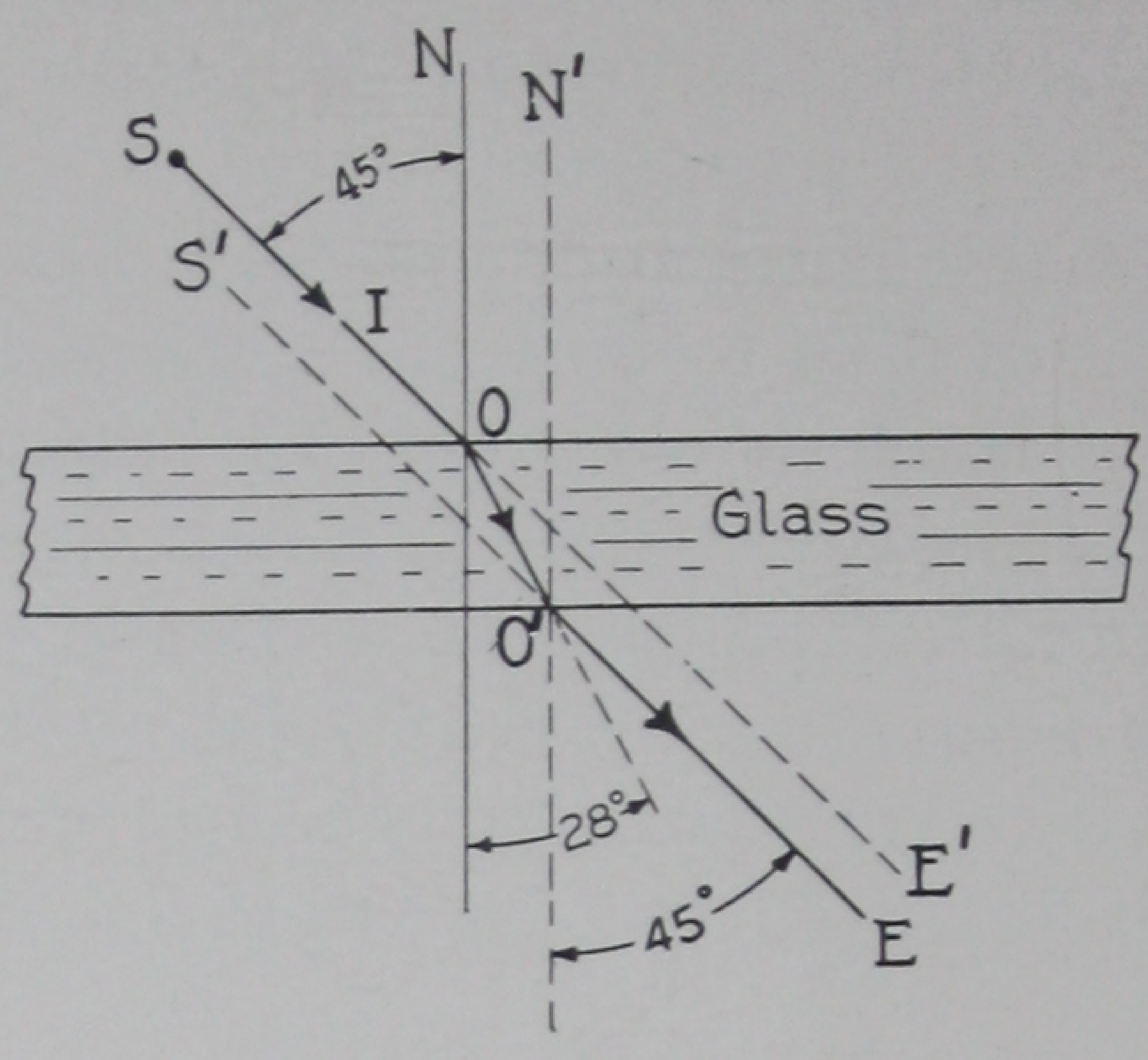


FIG. 6. By refraction is meant the change of direction of a light ray in passing from one transparent medium to another of different density. With the kind of glass shown, a ray entering at an angle of 45 deg. to the normal is bent downward to an angle of 28 deg. with the normal.

The control of light by means of refraction is accomplished by passing the light from a medium of one density through a medium of different density (Fig. 6). This method of control is used with the condenser and objective lenses used in motion picture projectors and stereopticons.

With the means of securing a concentrated beam of light outlined, let us touch on some of the most common uses for such beams and then study in more detail the particular apparatus involved.

Uses of Concentrated Light

Light concentrated into a beam is commonly used for such purposes as headlights on automobiles, locomotives, trolleys, etc. The more powerful sources are used for searchlight purposes in military and in marine work. Searchlight beams are also used to some extent to light billboards, signs, buildings, statues, etc., for advertising purposes.

For the latter class of work, however, the beams are generally spread considerably so as to cover a fairly large area and are then commonly known as floodlights.

An increasing use for the powerful, highly concentrated searchlight beam is for beacon purposes, to guide aviators to their landing fields. The U. S. Air Mail Service, for example, has a 2,000,000 cp. beacon every 25 miles along the course across the continent. Small searchlights are also used to some extent for signalling purposes.

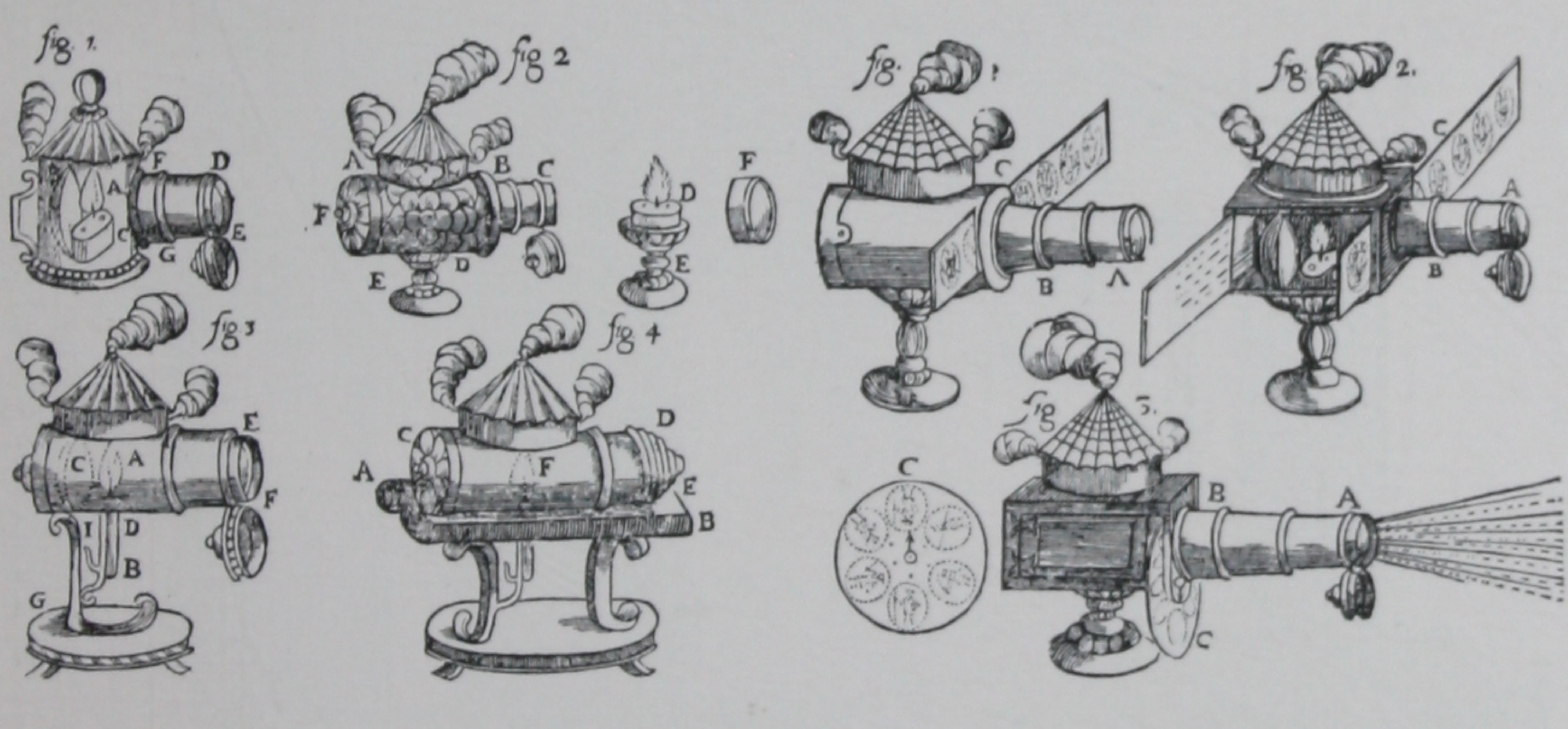
Another common use for highly concentrated beams is for spotlight work. Present theatre lighting practice involves the use of large numbers of spotlights. Due to the necessity of quickly and easily changing the beam from a small concentrated head spot to a wide spread floodlight, most theatre spotlights use plano condensers, and a light source that may be moved to various distances from the rear lens.

Another class of concentrated beam apparatus is that for projecting pictures—both still and moving.

Stereopticons

The general principles of what is today known as visual instruction were laid down by Comenius more than 300 years ago in his "Orbis Pictus." A century later Pestalozzi advanced beyond the picture stage by insisting that teachers must either bring reality into school for study or take the children out to see reality.

In many Latin writings, between the years 1500 and 1700, we find the projection lantern described as "camera obscura" or



"lanterna magica." Who the inventor was seems to be unknown. Various forms of magic lanterns are shown in Zahn's Latin book, "Artificialis Teledioptricus," published in the year 1685. These crude little devices were forerunners of the modern projection instruments. The principal difficulty in developing suitable projection apparatus at that time was the utter lack of efficient illuminants. Sunlight was about the only form that was sufficiently bright, and that was impractical. The above sketches from Zahn's book suggest that oil lamps were used, and at the right is shown how the "machines" were constructed to carry a series of slides.

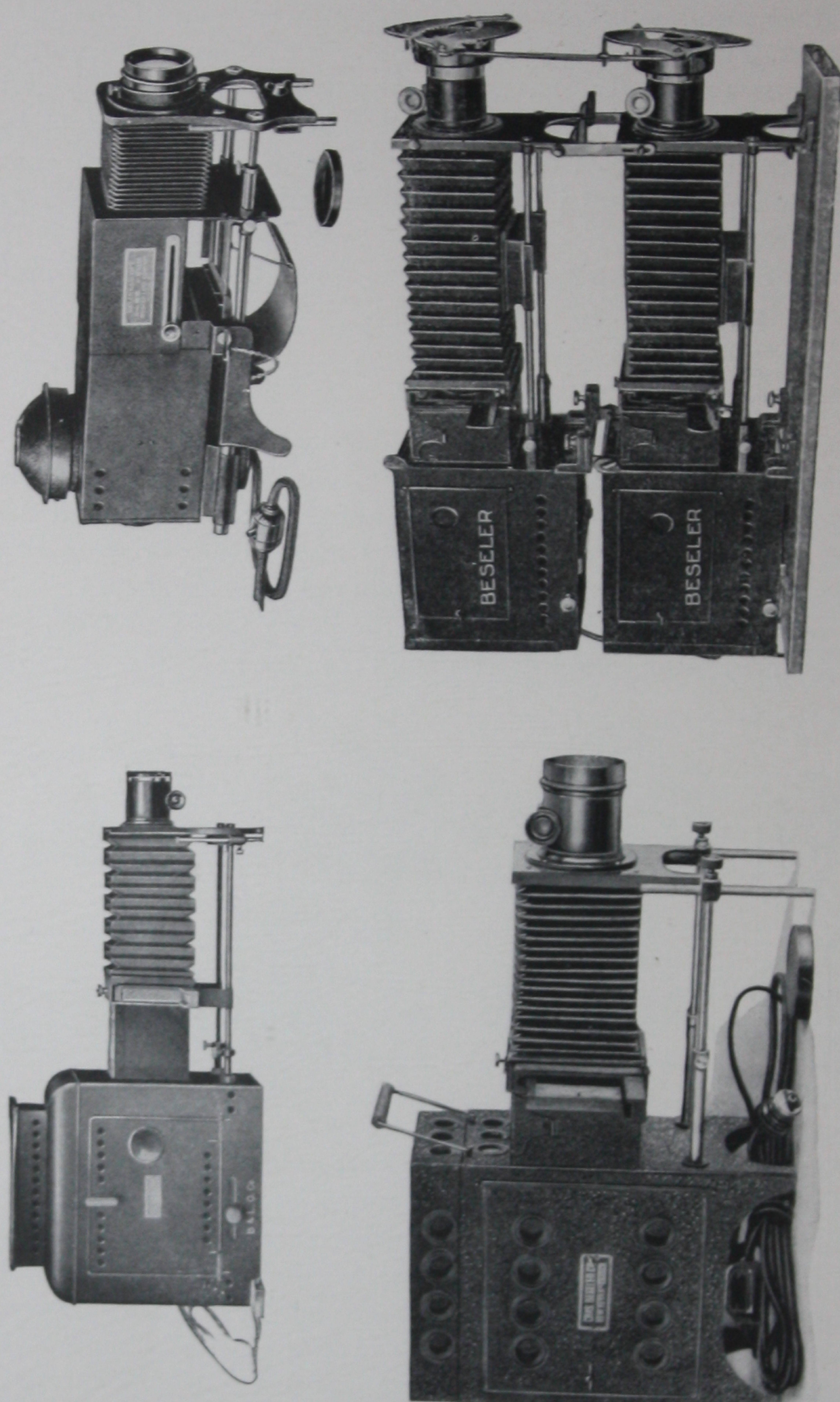


FIG. 7. Stereopticons designed for use with glass slides. It is now possible to employ the more convenient film slides in these lanterns by using the adapters shown in Fig. 8.

It was inevitable that when our modern scientific educators began the study of the most absorbing forms of the laws of the human mind, their attention should be directed to the fact that the greater part of our information depends upon sight. Nor was it surprising that the new departments of visual instruction should

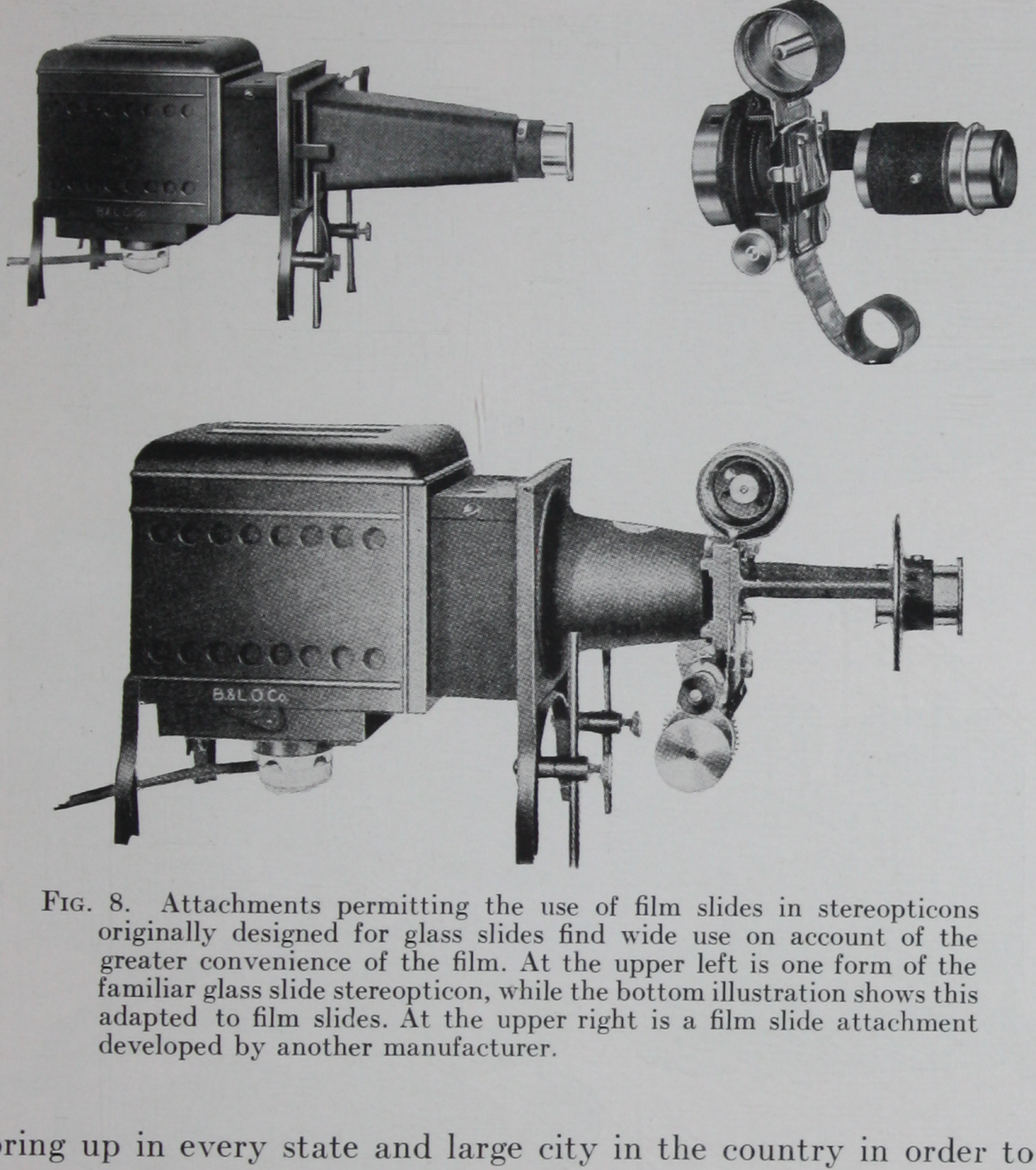


FIG. 8. Attachments permitting the use of film slides in stereopticons originally designed for glass slides find wide use on account of the greater convenience of the film. At the upper left is one form of the familiar glass slide stereopticon, while the bottom illustration shows this adapted to film slides. At the upper right is a film slide attachment developed by another manufacturer.

spring up in every state and large city in the country in order to develop and systematize this growing force in present-day education.

The most common forms of stereopticons use glass slides. These, however, are heavy and cumbersome. (Fig. 7.) There is a rapidly growing trend towards the use of slides made on motion picture film. The 35 mm. width is generally used. There are available attachments for the older slide lanterns (Fig. 8), which make possible the use of film slides in these lanterns.

Much smaller and lighter projectors, built specially for film slides, are finding wide application for use by salesmen and lecturers in the home, office, and class room. (Fig. 9.) Such film slide projectors can be used for pictures up to 4 ft. size, 25 ft. throw.

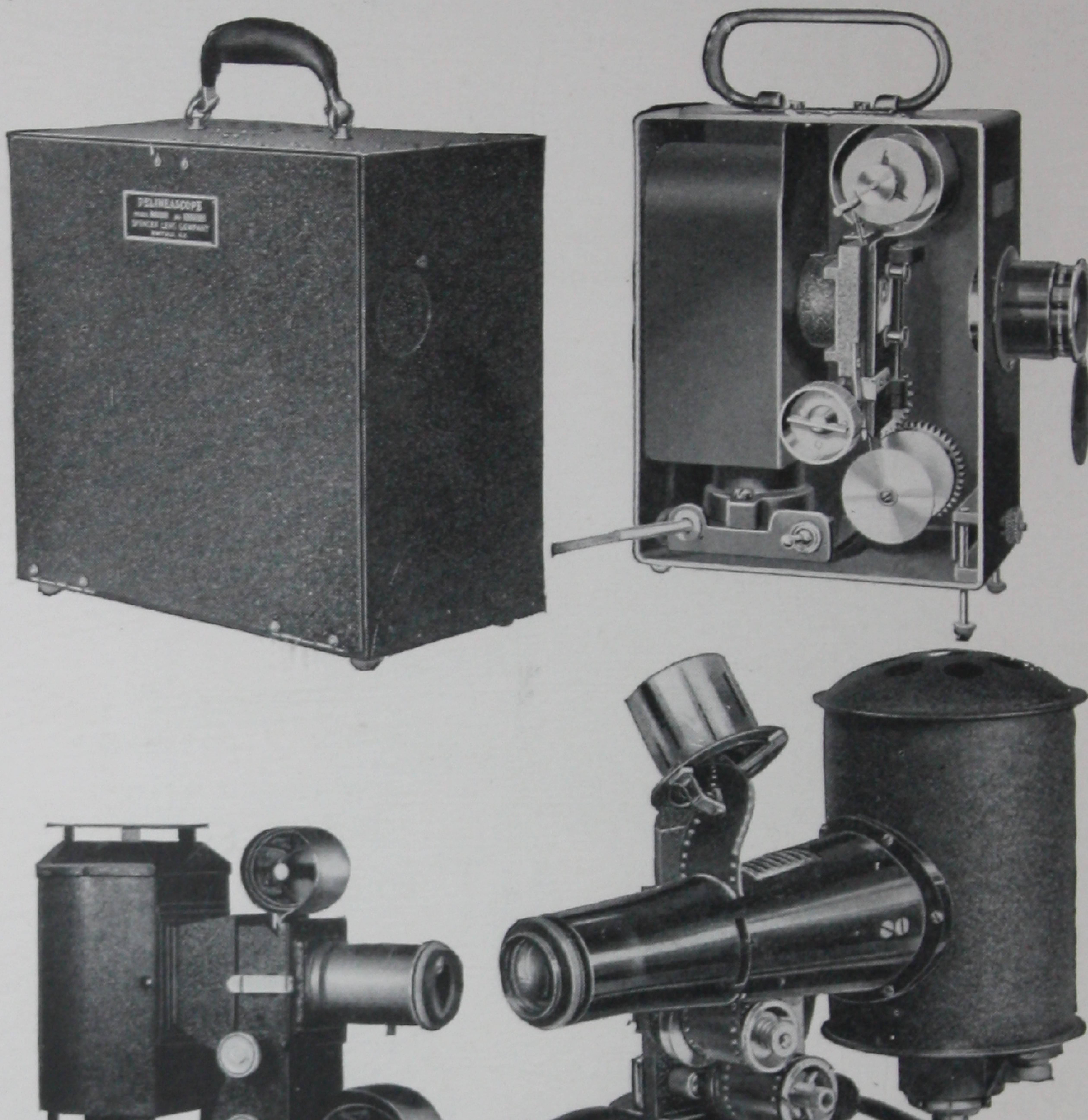
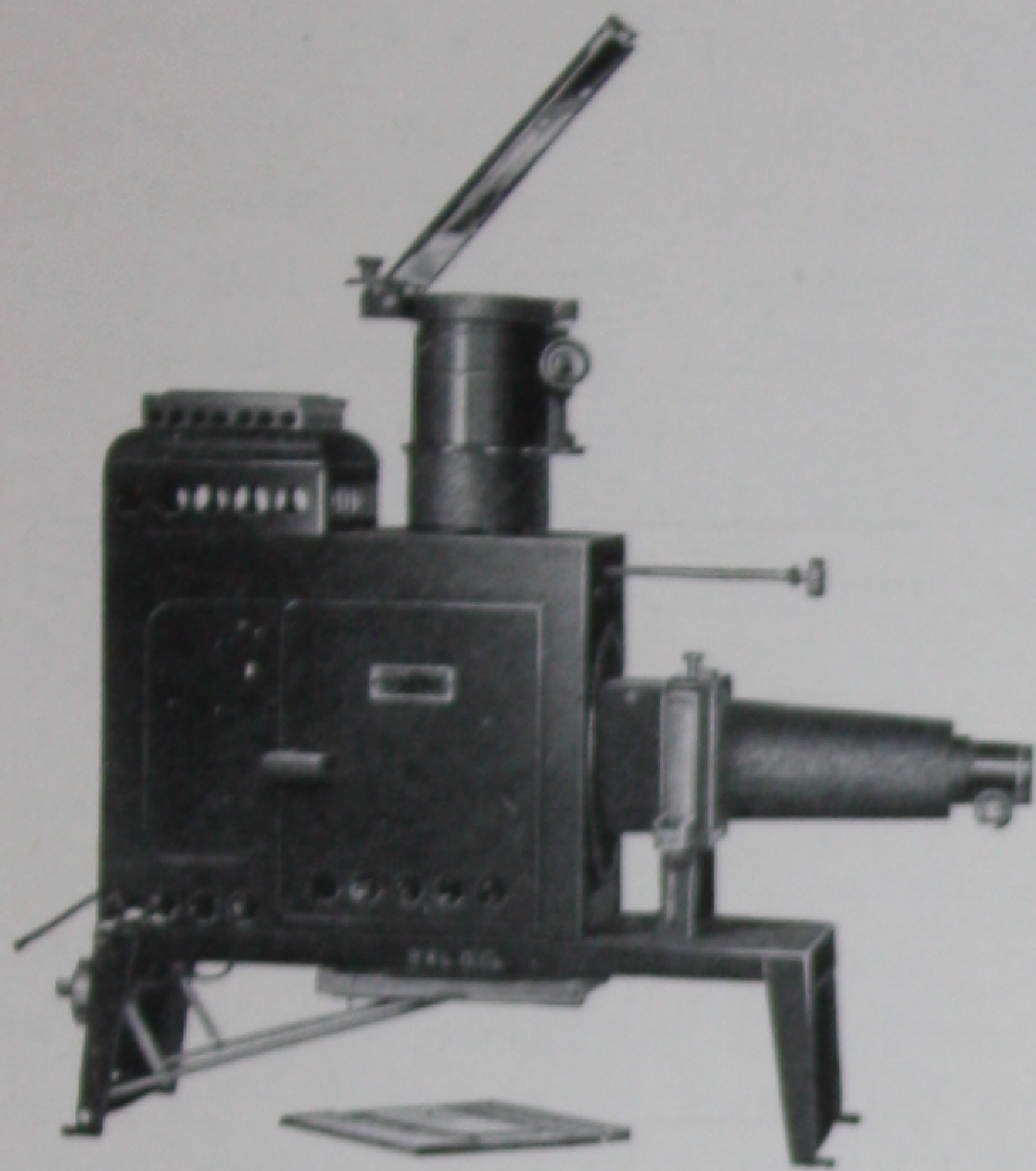


Fig. 9. Salesmen and lecturers find small film slide projectors convenient to carry. At the upper left is an automatic type in which the pictures may be changed by remote control, the operator pressing a button connected by a flexible cord with the projector. Also, the machine is designed to show the entire series of pictures automatically, repeating at the end.

Some of the film slide projectors use low voltage lamps (12-16 volt, 21 cp. automobile headlamps), operated through resistance



cord. Others use the 100 watt, 115 volt, T-8½ bulb lamps direct from the lighting circuit. The glass slide stereopticons generally use the 500 watt, 115 volt, short T-20 bulb lamp.

In motion picture theatre work there is sometimes an auxiliary stereopticon lens for the projection of slides and sometimes a separate stereopticon is used. (Fig. 10.)

Fig. 10. Current designs of stereopticons offered by one manufacturer. That at the right is fitted with dissolving view equipment.

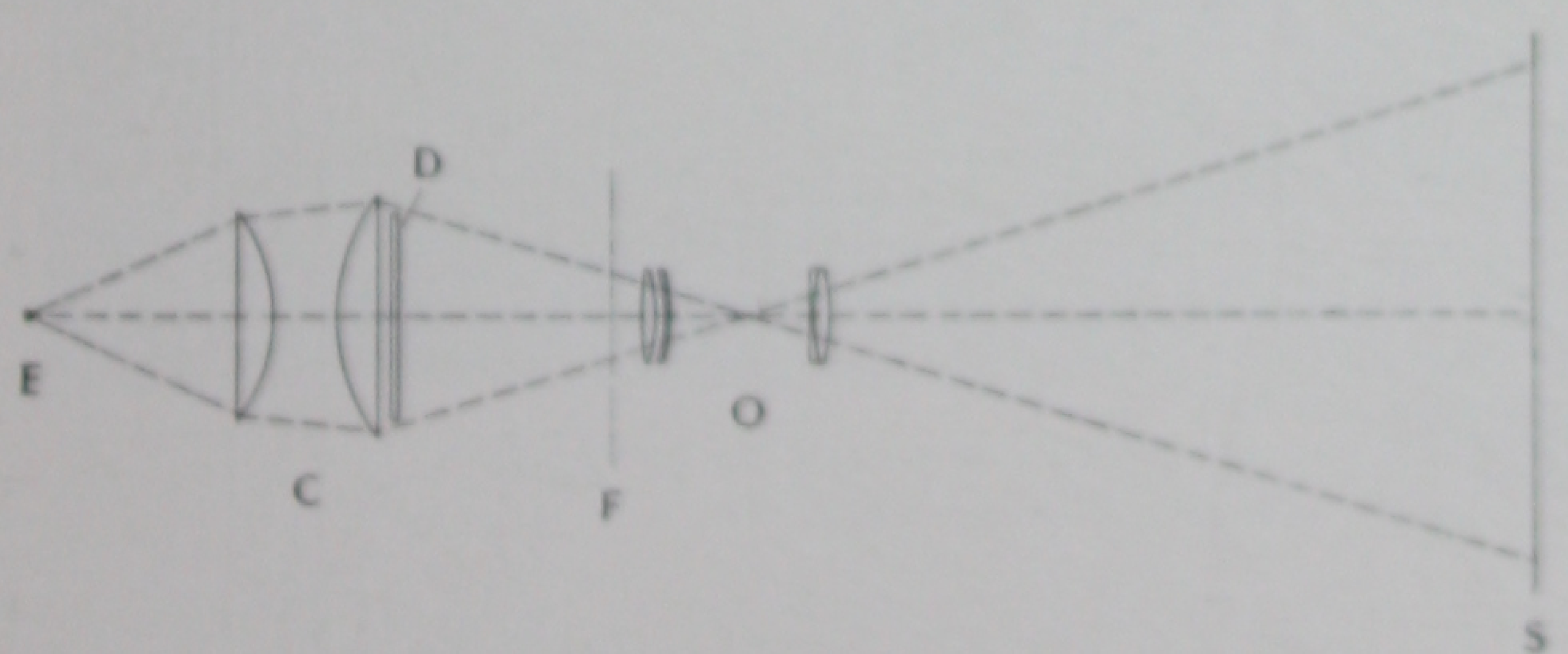


Fig. 11 (*left*). Typical optical system of a stereopticon.

Path of Light in Lantern Slide Projection Legend: E—Illuminant; C—Condensing System; D—Slide; F—Diaphragm; O—Projection Lens (or objective); and S—Screen

FIG. 12. Typical motion picture projector showing positions of lamphouse and regulator.

Motion Picture Projectors

Motion picture projectors may be divided into three general types: (1) the large machines for theatre use (Fig. 12); (2) the suit-case semi-portable types for use in schools, churches, lodge halls, etc. (Fig. 13 A, B, and C); (3) the small home projectors (Fig. 14).

A machine of the first class generally uses 35 mm. inflammable film, and in most states the fire laws require its use in a fireproof booth and a licensed projectionist to operate it.

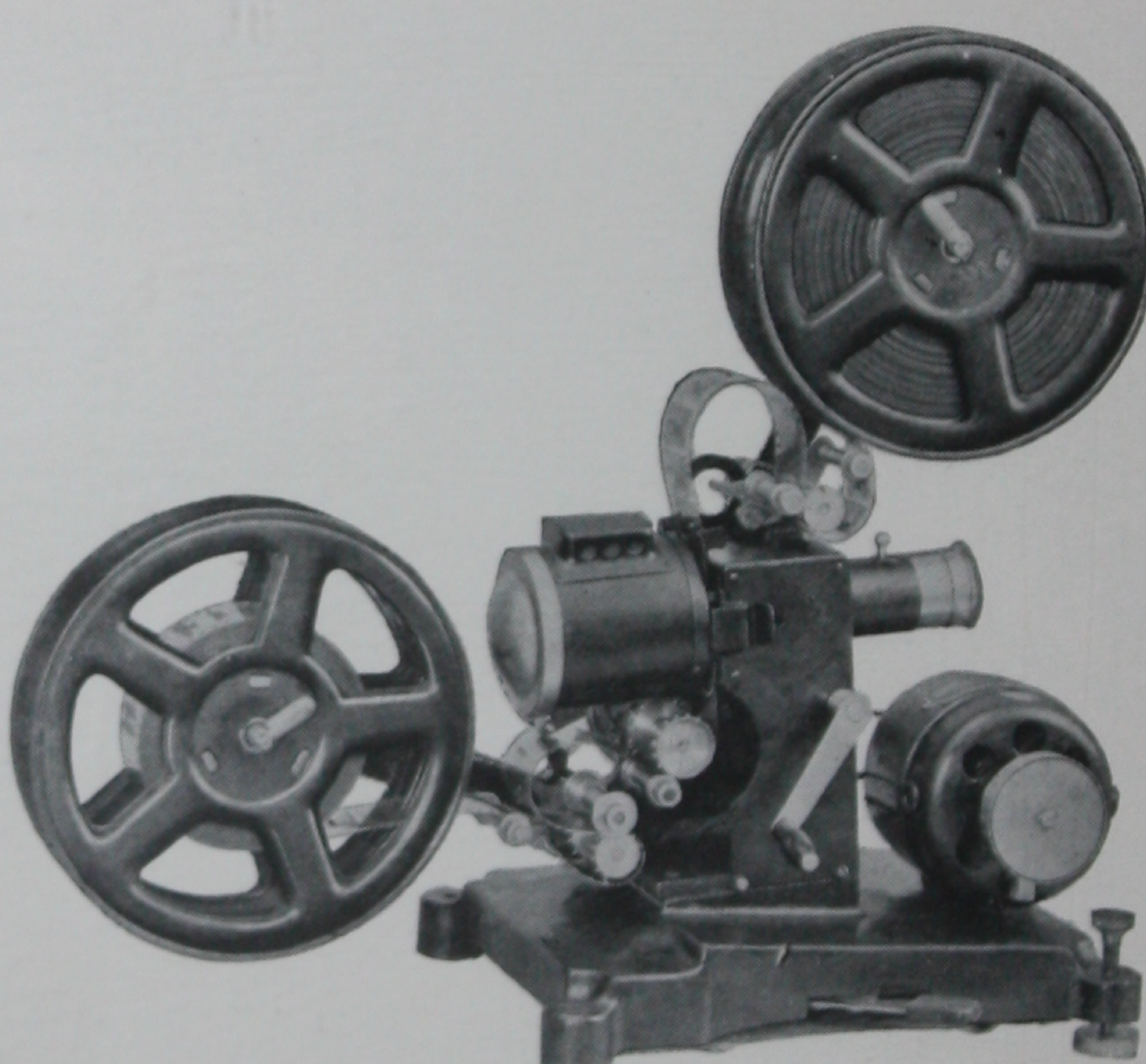


FIG. 13A. The semi-portable projector is widely used in schools, auditoriums, etc.

Other representative types of semi-portable projectors. In Fig. 13B a design is shown in which a film magazine is provided in the hollow base. The machine shown in Fig. 13C is designed with respect to portability, and the case may be locked to prevent tampering.

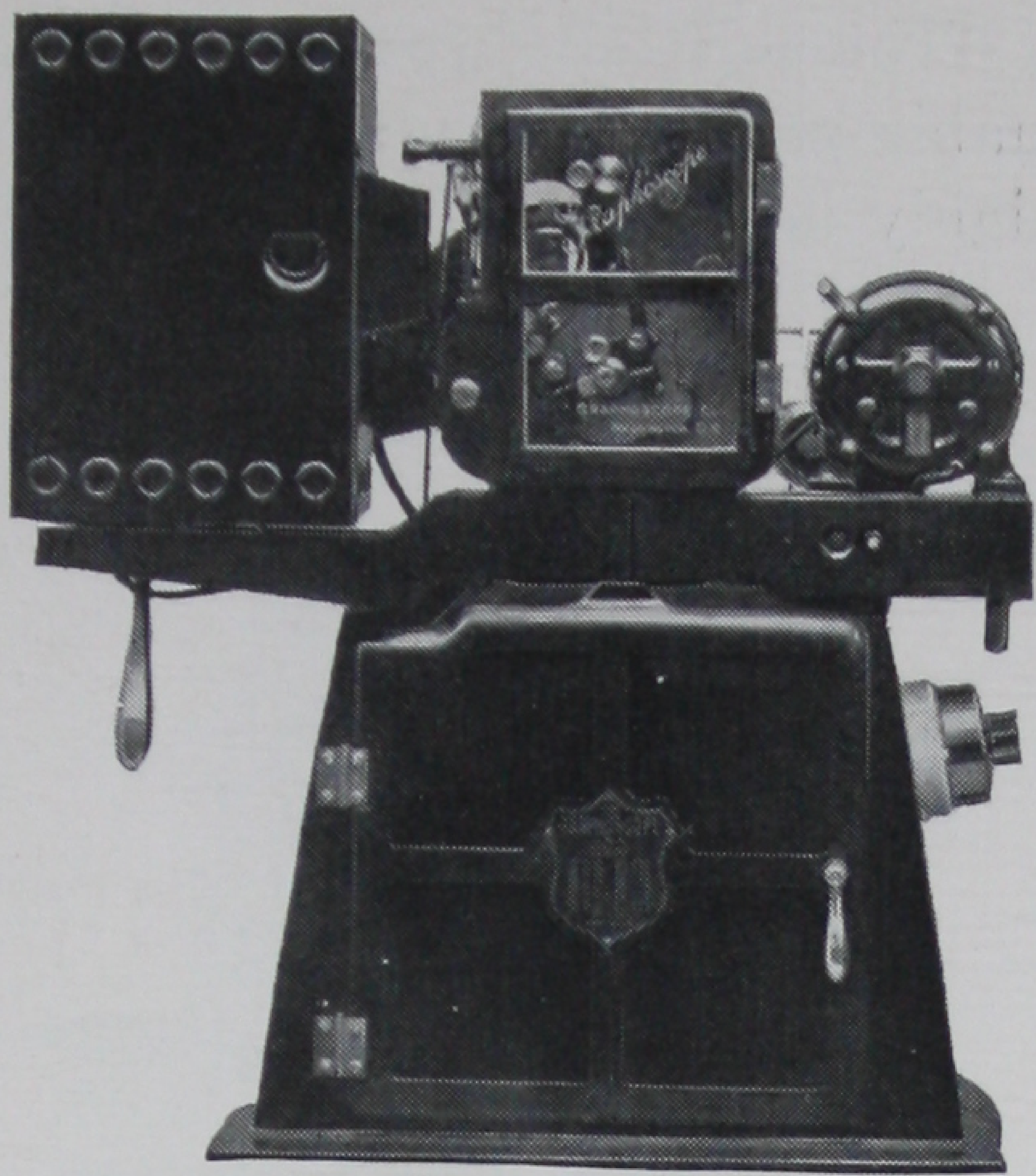


FIG. 13B

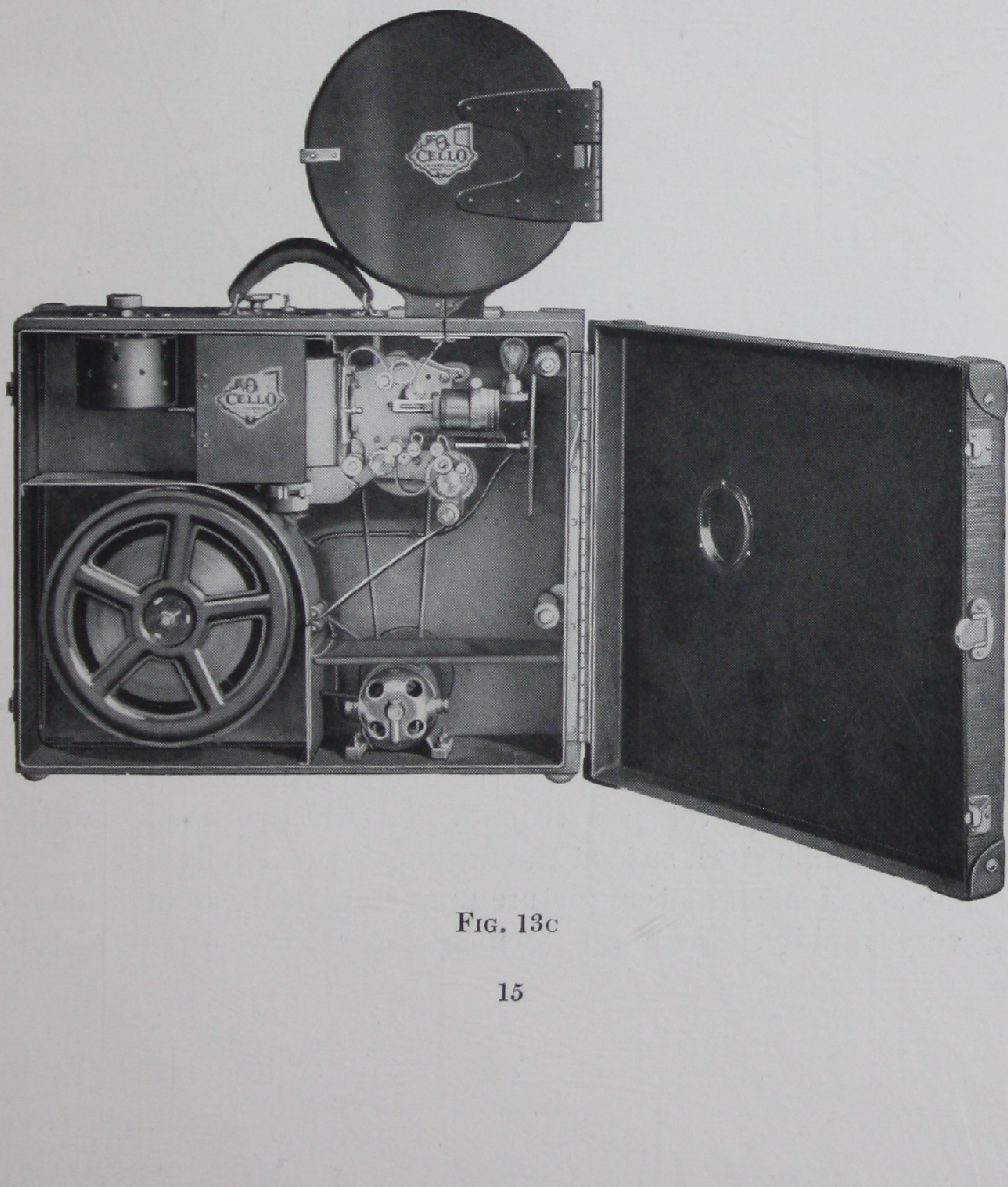


FIG. 13C

The suit-case type projector generally uses 35 mm. non-inflammable or slow burning film, but it has the disadvantage that the highly inflammable film also may be employed.

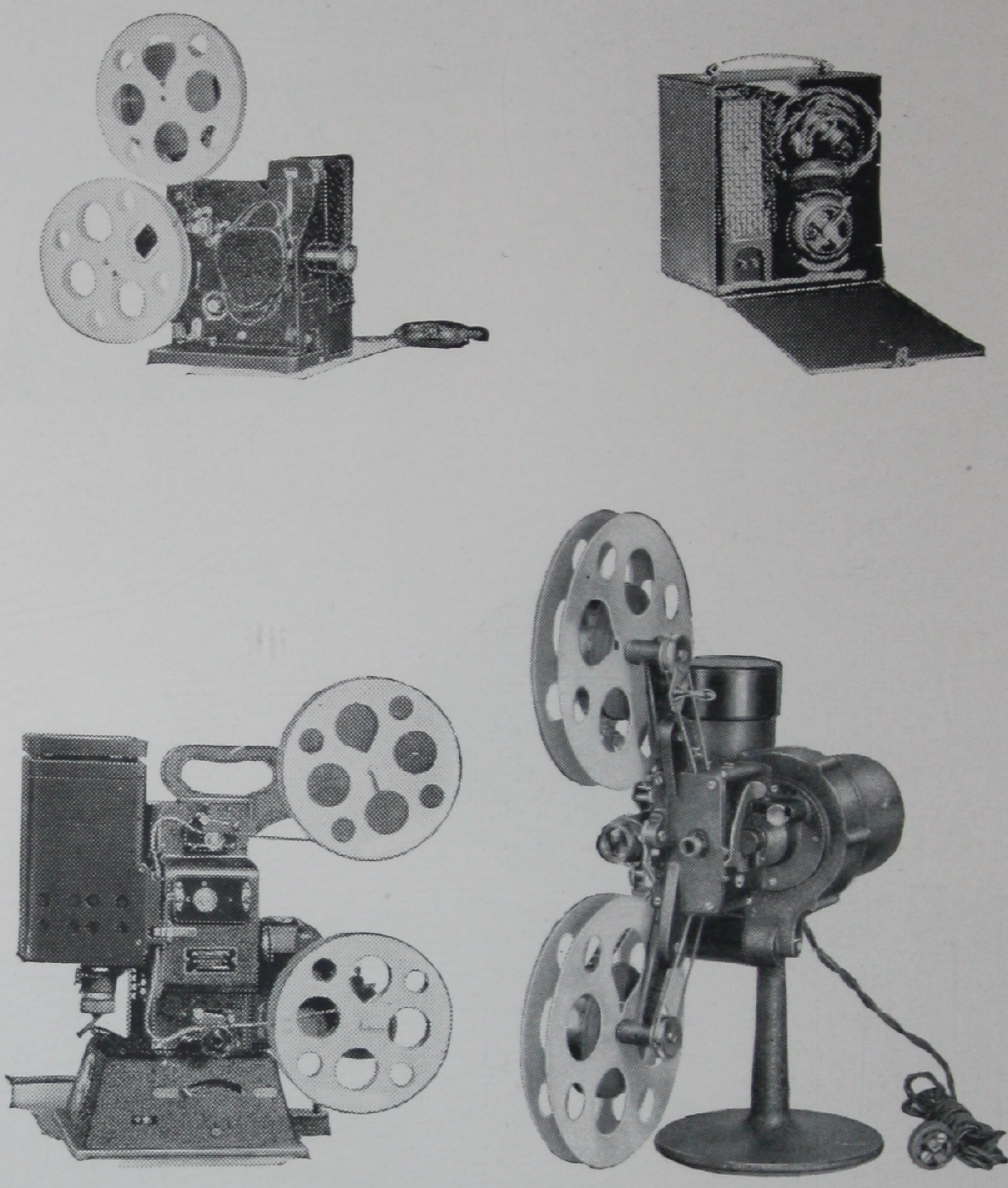


Fig. 14. The use of small projectors in the home is rapidly increasing in popular favor. When these are used in conjunction with the amateur motion picture camera, interesting incidents of trips are readily portrayed to groups of appreciative friends. Several of the designs available are illustrated above.

The home projector uses 16 mm. film which is made only in non-inflammable stock so that the fire risk is practically nil.

The use of small motion picture projectors in the home is growing very rapidly. There are available excellent motion picture

cameras not much larger than the ordinary Kodak (Fig. 15). These make it possible for the amateur to take his own pictures as readily as he previously took snap shots with the Kodak. As an

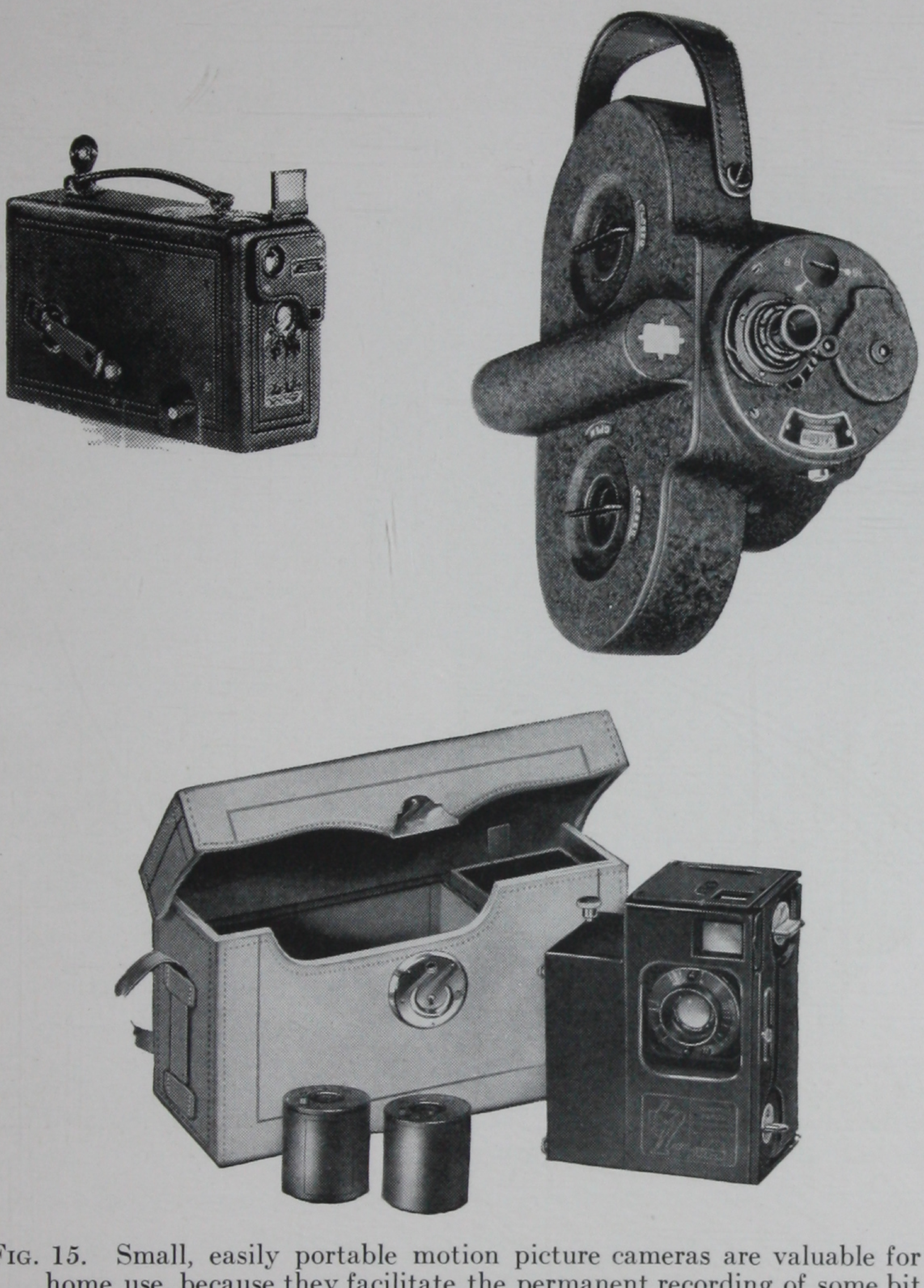


Fig. 15. Small, easily portable motion picture cameras are valuable for home use, because they facilitate the permanent recording of some bit of action, interesting in itself or worthy of preservation through its associations.

indication of the extent to which the amateur motion picture camera is coming into use, it is interesting to note that during 1926 there were 35,000 amateur motion picture cameras sold in this country, and 60,000 miles of film were purchased.

By a clever reversal process, the same strip of film that is used as the negative in the 16 mm. film camera is used for the positive in the projector, thus greatly reducing the cost. The purchase price of the film covers developing service by the manufacturer and return postage.

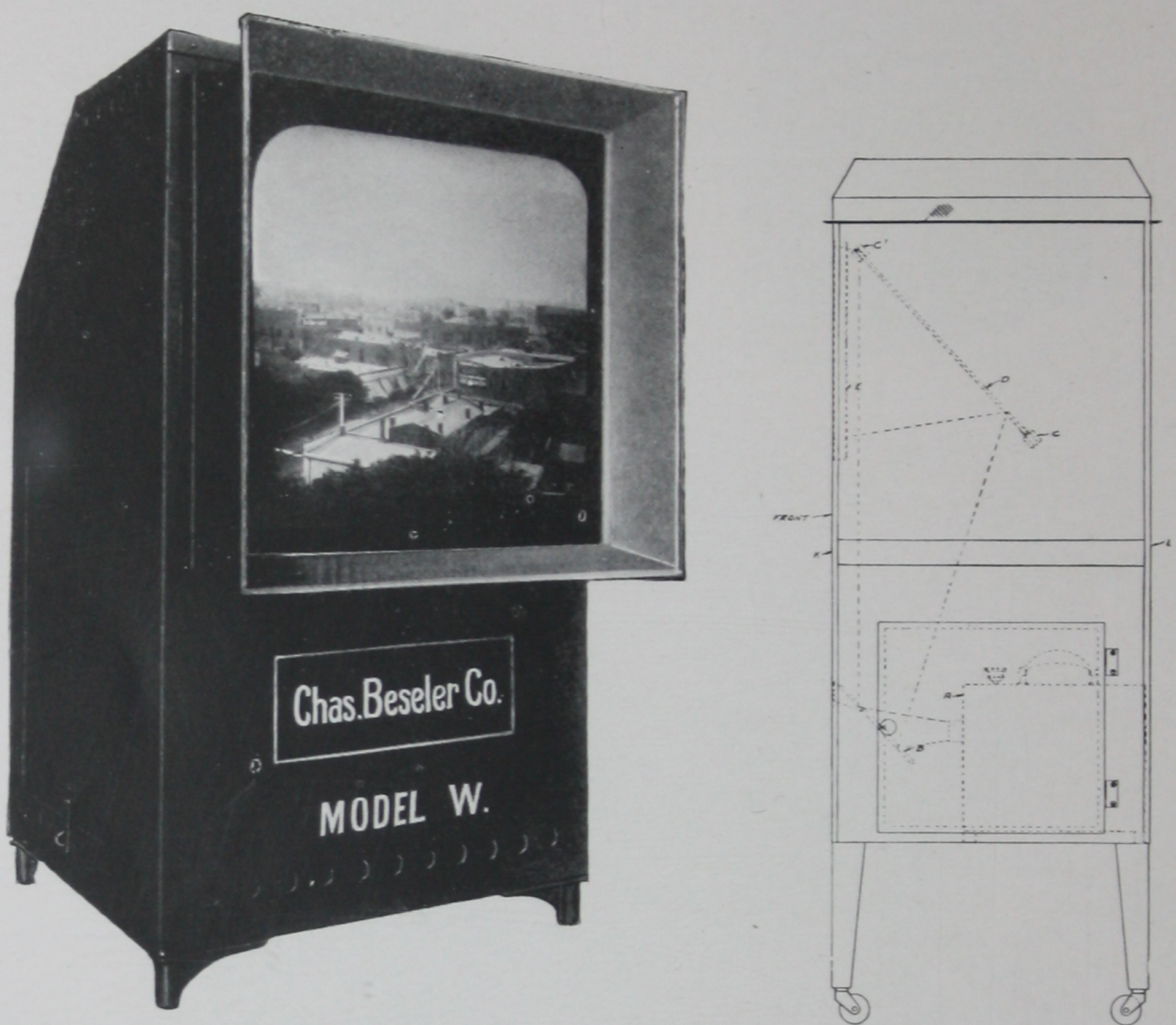


Fig. 16. Projectors, using either still or motion pictures, are finding wide application in the advertising field. In these, the pictures are automatically repeated when the end of the series or of the film is reached.

In addition to taking one's own pictures, there is available a very fine film library, the Kodascope Library, with offices in the principal cities, from which films can be rented for a nominal sum. A wide variety of subjects is available in this library. They can be ordered from the catalogue, are sent by mail, and after use, returned in the return-addressed box that comes with them for the purpose. Some of the projector manufacturers also have excellent educational film libraries to service their machines.

There is a third size of film, still smaller, that is used in the Pathex projector. The old 28 mm. safety standard film has gone almost entirely out of existence, being replaced by the 16 mm. size.

Another class of projector is used to considerable extent, that is, the advertising projector for use in store windows, etc. These devices show either a series of still pictures, automatically changing from one to another, or else a motion picture, automatically repeated over and over again (Fig. 16 and frontispiece).

Perhaps it would be well, at this point, to consider in more detail the optical train of motion picture projectors and point out wherein and why, when a Mazda lamp is used as a light source, the lens system varies somewhat from that used with an arc.

Optical Train

Let us base our data on the 900 watt, 30 volt Mazda lamp which is the standard light source for theatre projection.

The arc emits light by reason of the glowing crater on the end of the positive carbon. Once sufficient current is reached in the carbon to fill the crater, there is very little increase in brilliancy due to increased current.

A Mazda lamp, on the other hand, emits light by reason of the glowing tungsten filament. The hotter this filament, the more brilliant the emitted light. There is, however, a limit to which the filament can be heated without melting, and thus destroying the lamp. Tungsten melts at about 3655° K. Even before it reaches the actual melting point the filament starts to disintegrate; in other words, minute particles fly off from the surface. The rate of this disintegration determines the life of the lamp, that is, the higher the temperature, the shorter the life. Also, the higher the temperature, the higher the brilliancy of the emitted light, and the greater the candlepower of the lamp. This means that the Mazda motion picture lamp should be operated at a sort of compromise between these two factors; that is, at a point where it will be very brilliant and yet have a reasonable life.

Taking into consideration the cost of current to run the lamp, the cost of lamp renewals, and the illumination obtained on the screen, 100 hours has been determined as the most satisfactory life for this lamp. This is obtained in the 900 watt motion picture lamp at about 3290° K filament temperature (maximum). At this temperature the lamp has an efficiency of 27.3 lumens per watt, and a

filament brilliancy of 2660 candlepower per square centimeter. As a matter of interest, the brilliancies of other light sources run about as follows:

Candle	½	cp. per sq. cm.
Kerosene flame	1¼	" " " "
Acetylene	15	" " " "
50 watt Mazda B lamp	205	" " " "
1000 watt Mazda C lamp	1195	" " " "
900 watt motion picture lamp	2660	" " " "
Crater of carbon arc	18,000	" " " "
High intensity arc	50,000	" " " "
Sun arc	165,000	" " " "

The Mazda motion picture lamp is operating only 365° below the melting point. It is, therefore, absolutely essential to maintain the current very accurately at its normal value of 30 amperes. If the current in the lamp is allowed to exceed that value the life of the lamp will be shortened in about the following ratio:

30	amperes	100%
30.25	"	80%
30.50	"	66%
30.75	"	55%
31	"	45%

On the other hand, if the current is allowed to fall below 30 amperes, the candlepower of the lamp decreases about as follows:

29.75	amperes	95%	cp.
29.50	"	90%	"
29.25	"	86%	"
29.00	"	81%	"

So let us again emphasize the necessity of maintaining the lamp current very accurately at 30 amperes.

Now let us see wherein, and why, the optical system for use with the Mazda lamp varies from that of the arc. At first glance, it seemed considerable to expect to replace an arc operating at a brilliancy of 18,000 candlepower per sq. cm. with a Mazda lamp operating at but 2660 candlepower per sq. cm. It has, however, been successfully accomplished in this manner:

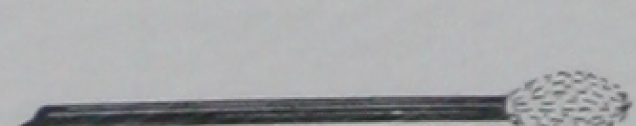


Fig. 17A

The crater of the arc emits light *only* forward; the distribution being about as shown in Fig. 17A.

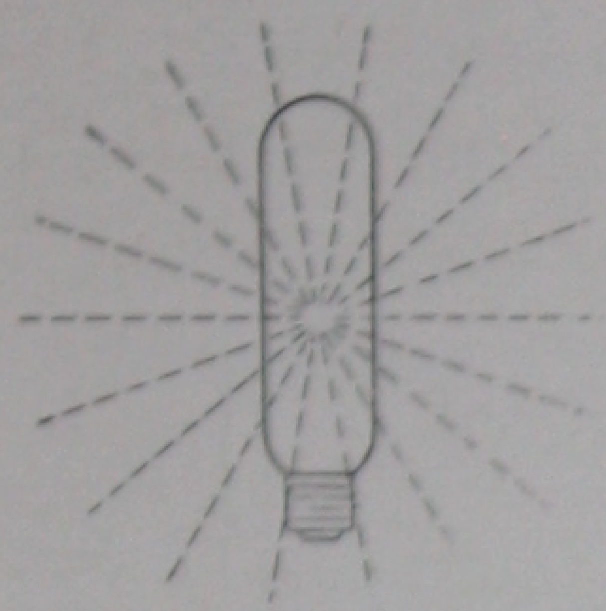


Fig. 17B

With such a distribution, the 10 in. or 12 in. focus plano condensers and a 1½ in. diameter projection lens collect and utilize practically all of the light. On the other hand, the Mazda lamp emits light very nearly equally in all directions (Fig. 17B).

Obviously, if the Mazda lamp is simply substituted for the arc, only a small portion of the total light emitted will be utilized (Fig. 18A).

Therefore, in order to intercept more light, a much shorter focus condenser must be used. At first, a single piece corrugated condenser (Fig. 18B) was used, and later a triple lens aspheric condenser (Bausch & Lomb Cinephor, Fig. 18C). Such condensers

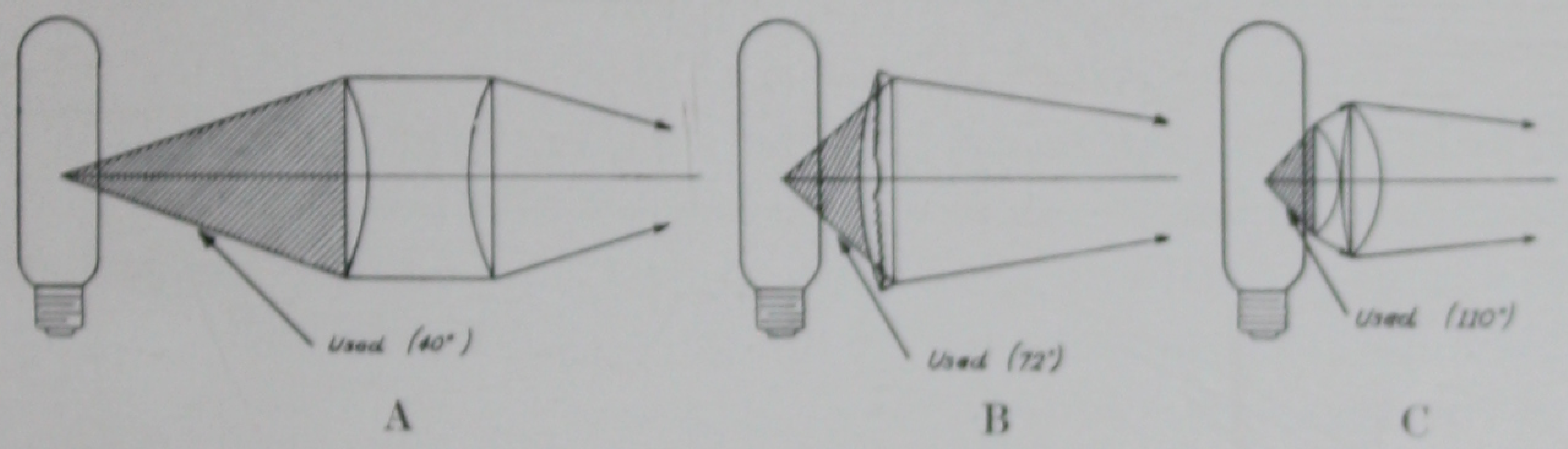


Fig. 18. The addition of a suitable lens makes possible the utilization of a much greater portion of the light from a projection lamp.

pick up a solid angle of light of about 110°, as against 40° for the old plano condensers. In order to utilize the light which is given off to the rear of the lamp, a spherical mirror is placed behind the bulb, and so adjusted as to reflect an image of the filament coils back between the coils themselves. Thus instead of the 60° picked up in the arc system, we are utilizing the equivalent of 220° of solid angle. It is very important that the spherical mirror be accurately adjusted, in order to secure the best results. Fig. 19 shows the lens settings for one of the condenser systems.

The use of short focus condensers projects the light through the aperture plate at a much wider angle than maintained with the long focus condensers. This being the case, the No. 1, or 1½ in., projection lens will not pick up and project to the screen all of this light (Fig. 20). In order to eliminate that loss, a larger diameter objective is essential. A No. 2 lens, 2½ in. diameter, will take

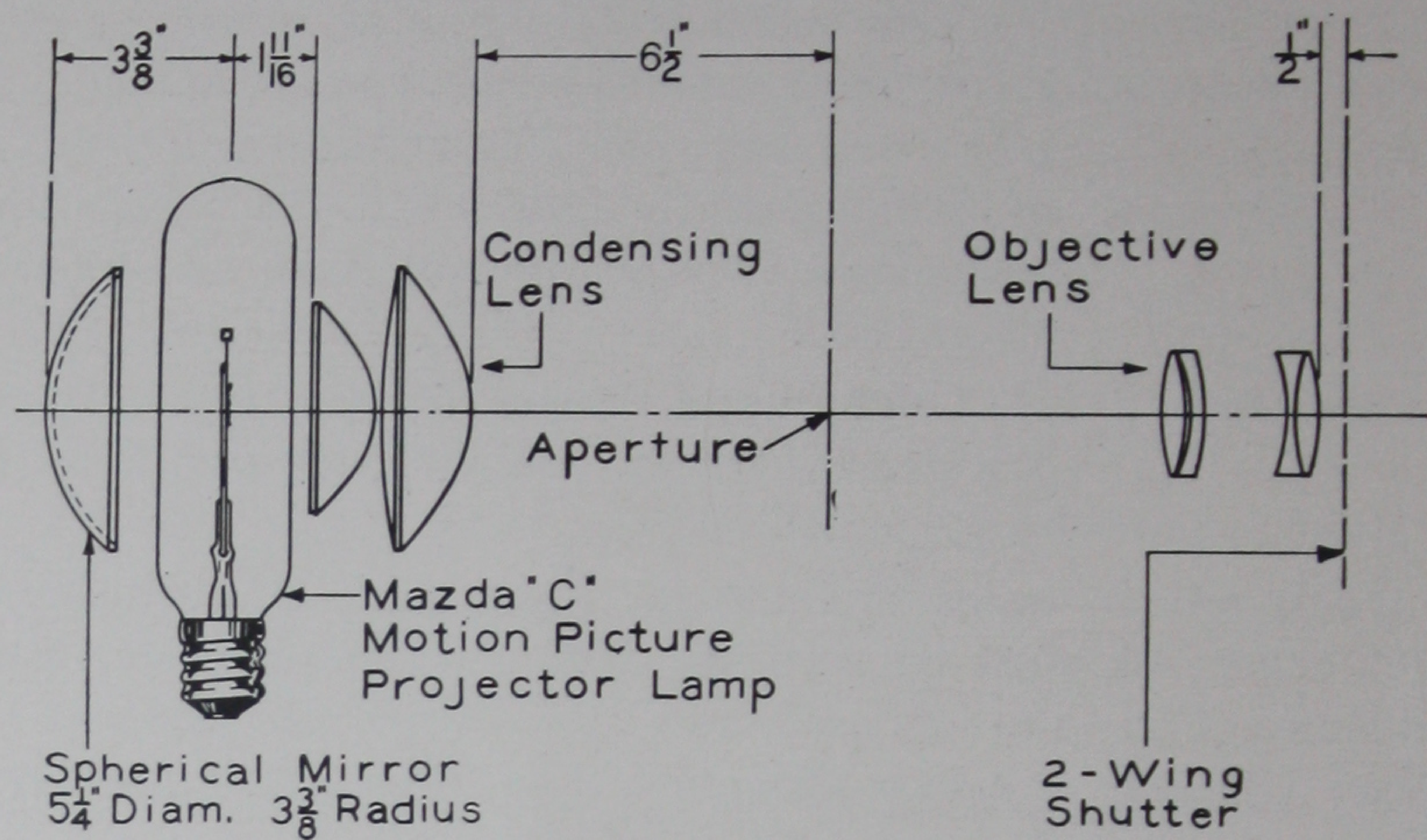


FIG. 19. Optical train using Bausch & Lomb Cinephor condenser.

care of this situation. No. 2 lenses are not recommended for shorter focal lengths than 5 in., as below that point their definition is not good. With MAZDA lamp projection, the increase in screen illumination obtainable by the use of No. 2 projection lenses instead of No. 1, is about as follows:

5½ in. Focus Lens............	95% Gain
6 in. " "	105% "
6½ in. " "	112% "
7 in. " "	112% "
7½ in. " "	102% "

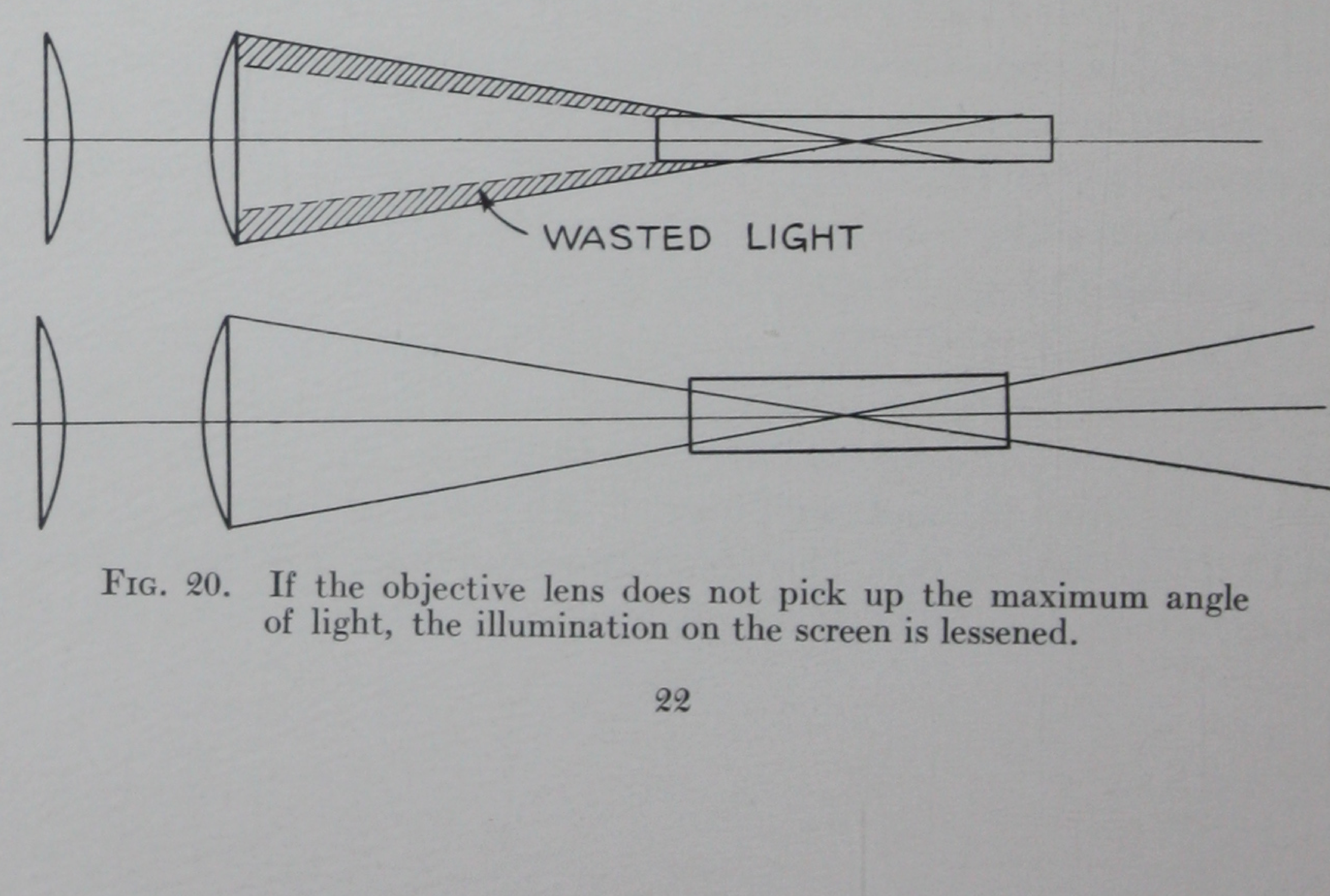


FIG. 20. If the objective lens does not pick up the maximum angle of light, the illumination on the screen is lessened.

There is one question that has been asked more or less frequently; that is, can the MAZDA lamp be used to advantage in the latest reflector arc types of projectors? The answer is, no. The reflectors of the reflector arc lamps intercept and utilize the majority of the light from the arc; but, due to the nearly spherical distribution of light from the MAZDA lamp, they would utilize a relatively small percentage of the total flux—much less than the aspheric condenser, spherical mirror system (Fig. 21).

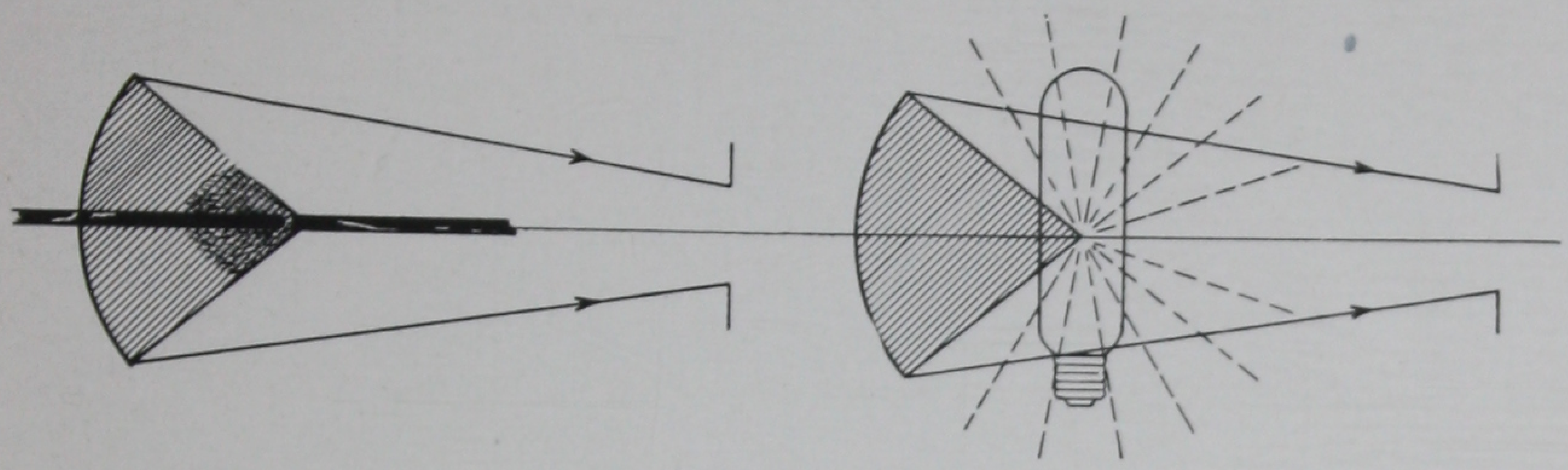


FIG. 21. The standard arc lamp reflector, when used with an incandescent lamp, redirects but a small part of the available light through the condenser.

Good results with MAZDA lamp projection necessitate not only the proper equipment, but also very accurate adjustment of the various elements of the optical system. A typical projection system is a tremendously inefficient thing. Only about 2 per cent of the total light generated reaches the screen without the film in the projector, and with the film this is cut still further. The losses of light through the optical train are about as shown in Fig. 22.

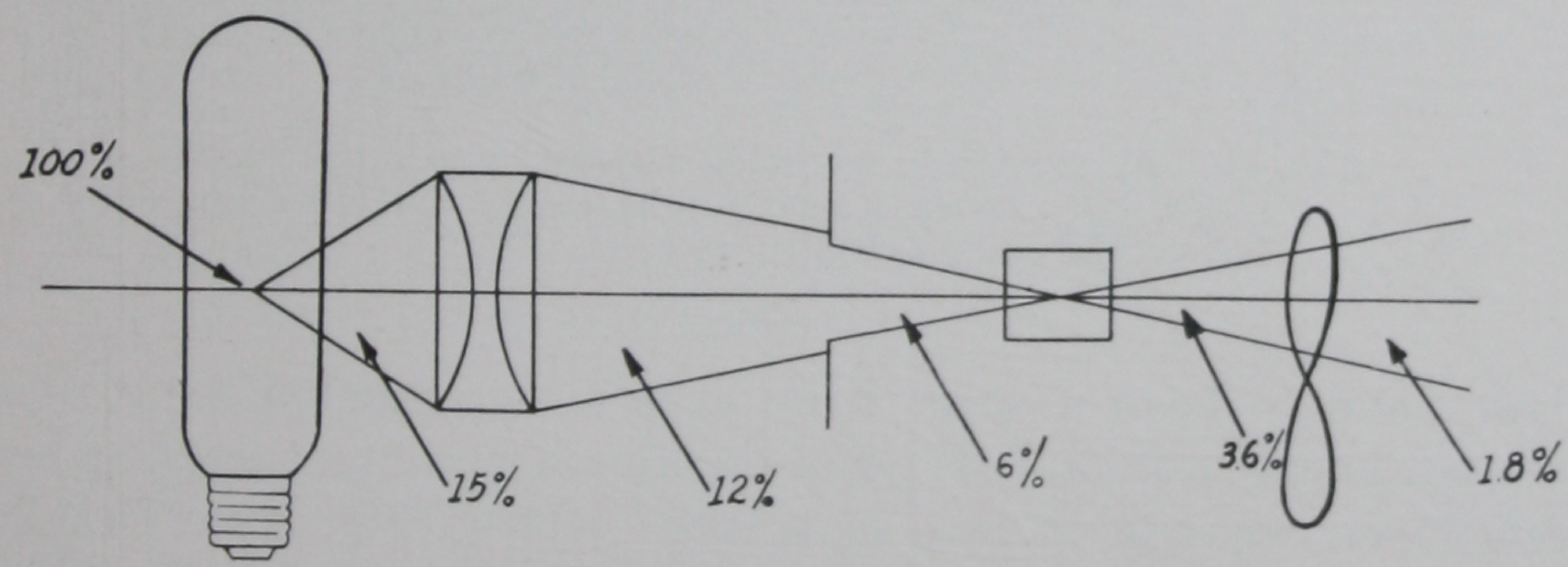


FIG. 22. On account of the losses in the optical train, only about 2 per cent of the total light emitted from the lamp reaches the screen.

By use of the latest type aspheric condenser, spherical mirror, and No. 2 projection lens, the light reaching the screen will be about 4 per cent of the total flux generated.

It is surprising what a large decrease in screen illumination results from very slight inaccuracies in the setting of either the light source or the spherical mirror.

To demonstrate this, all that is necessary is to run a section of film with the lamp set correctly, and then move it about a quarter of an inch out of adjustment. The decrease in picture brilliancy becomes very evident. In order to facilitate accurate setting of the

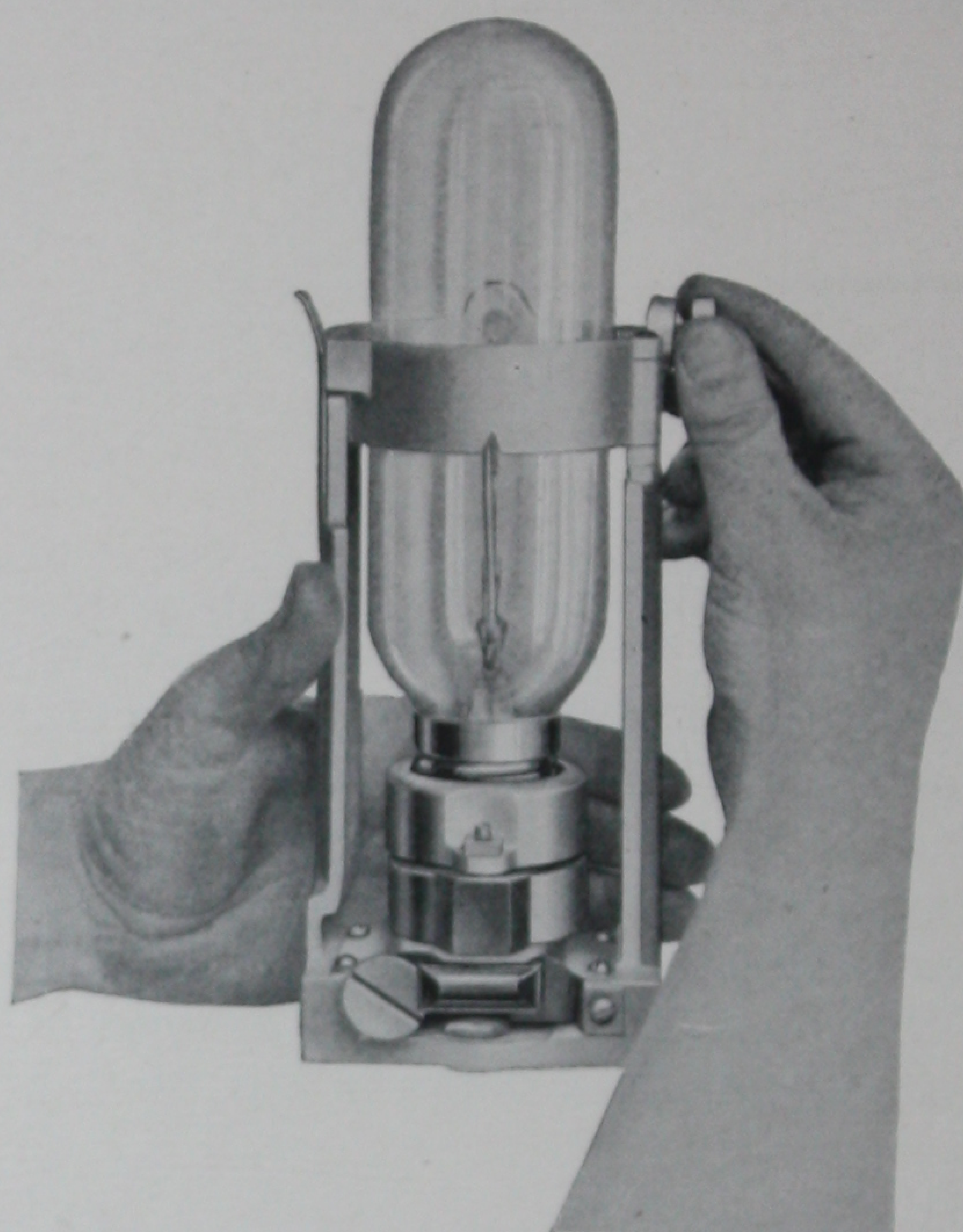


Fig. 23. By previously adjusting a spare lamp in the lamp setter, it is possible to make a quick change should a lamp fail while the film is being projected.

lamp, and to have a spare lamp accurately adjusted for a quick change in case a lamp fails when the film is running, there has been developed what is known as a lamp setter (Fig. 23). Detailed instructions for its use are given in the manufacturer's bulletins, so, suffice it to say here, that it is possible to adjust the lamp in any direction and then hold it there in a socket that can be slipped into the projector, with assurance that the light source will then come at exactly the correct position in the optical system (Fig. 24). This is necessary because lamps are made of various pieces of glass

joined together in a molten state and they cannot, therefore, be made with the accuracy that a piece of steel can be machined. The filament of one lamp may come a little higher above the base than that of the preceding one; the next may be slightly off sideways, etc. It is necessary to compensate for these differences with the lamp setter and the special socket.

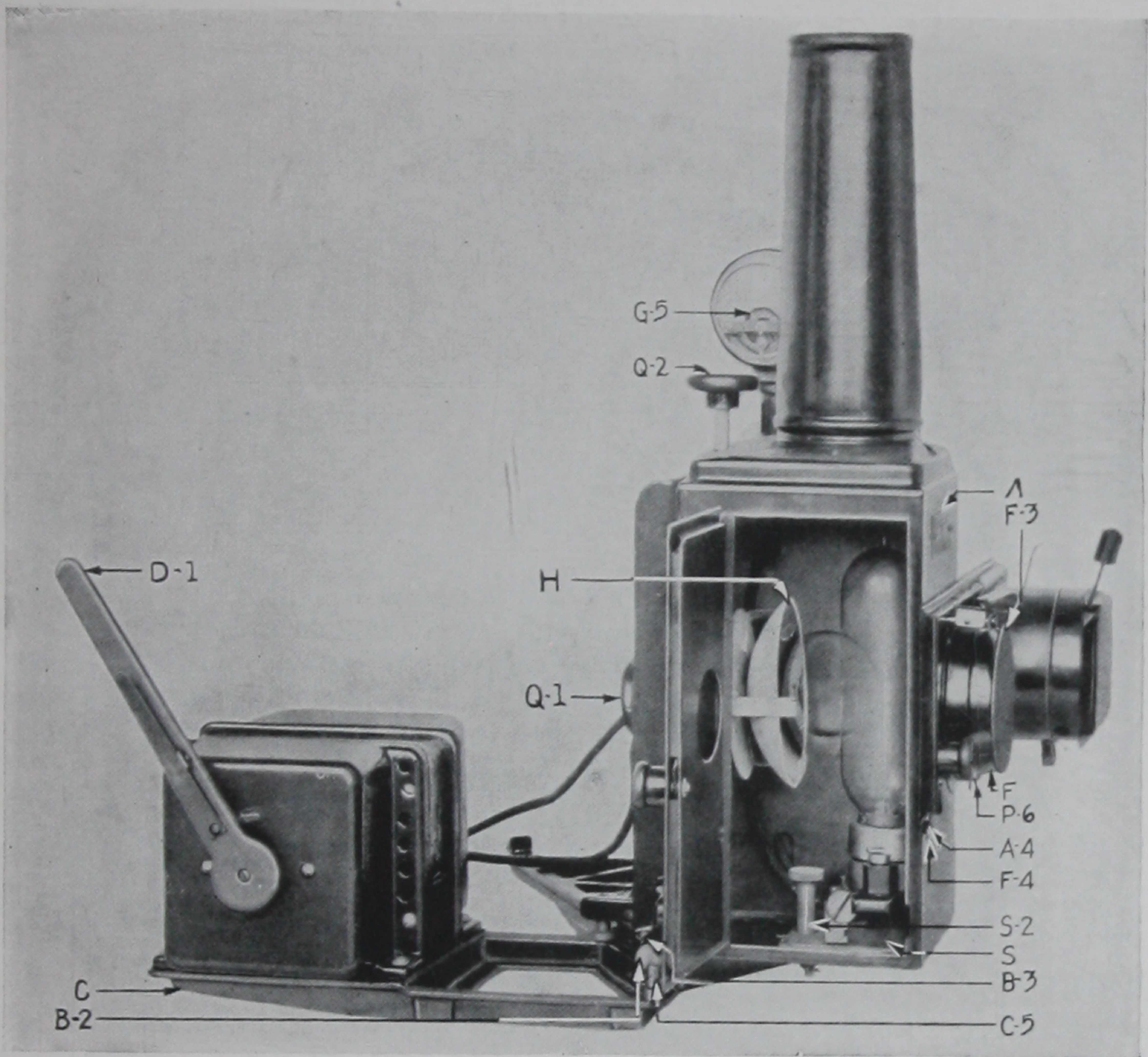


Fig. 24. After adjustment has been made in the lamp setter shown in Fig. 23, the socket and lamp are placed in the housing, the filament coming to exactly the correct position.

The MAZDA Motion Picture Lamp

There is another characteristic of Mazda lamps that it is well to note. That is, when the filament is hot, it is relatively soft. If the projector is working at a fairly steep angle, the lamp filament may sag or bow out (Fig. 25). In such cases, it is desirable to turn the lamp around each day so as to reduce this bowing to a minimum.

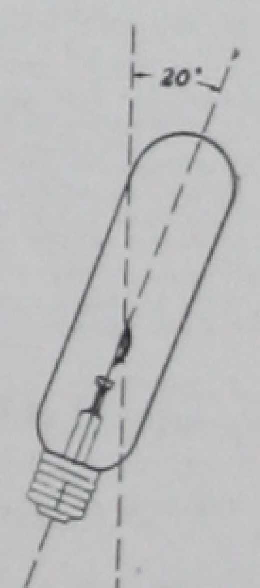


Fig. 25

The 900 watt, 30 volt MAZDA motion picture lamp will produce good pictures up to 18 ft. width at 125 ft. throw. It could, to advantage, be used in 90 per cent of the motion picture theatres today.

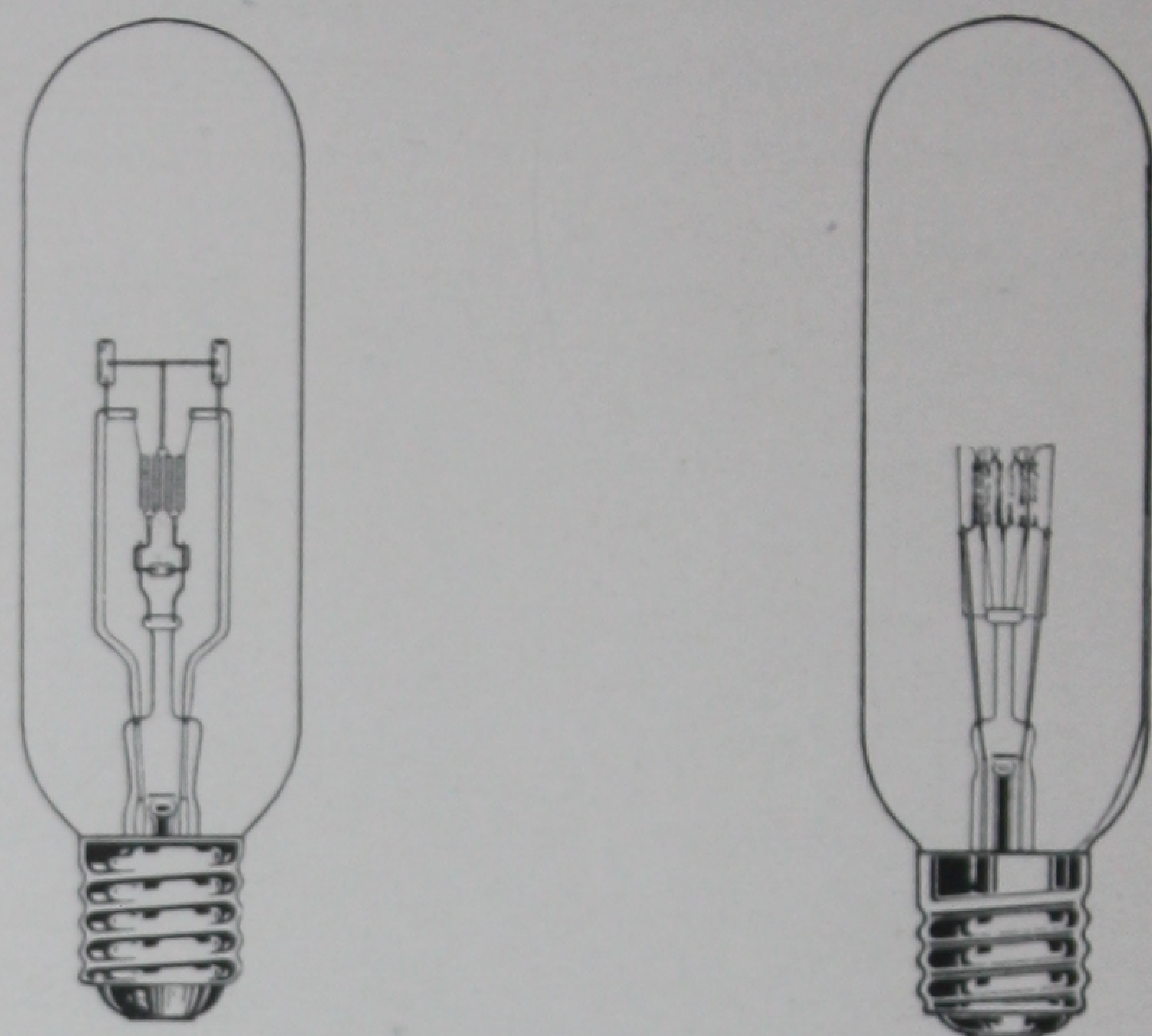


FIG. 26. At the left, a 28-32 volt, 900 watt, and at the right a 110 volt, 1000 watt MAZDA projection lamp. The lower voltage lamp, on account of the shorter length of filament and its lesser liability to squirm when heated, has the desirable factor of greater filament concentration.

Perhaps the reader wonders why 30 volt lamps are used, involving the necessity of transformers, etc., instead of 110 volt lamps, and also why higher wattage lamps cannot be used to handle the largest theatres. As to the 30 volt lamps, it is characteristic of tungsten filament that the higher the voltage, the smaller in diameter the wire must be, and the more it will squirm when it is heated and cooled. If 110 volt lamps were used we could not concentrate the filament into so small an area (Fig. 26), nor could we run it at quite so high a temperature. The greater filament concentration possible, with the low voltage high current lamp is, therefore, the prime reason for its use.

The useful size of light source is limited by the optics of the projector. The lens system will pick up light from a limited area and any light outside of this area is of no avail. It is a simple matter to determine the size of the useful source by back testing the lens system, that is, sending light backwards from the projection lens through the system.

This is done by placing a frosted lamp, or a clear lamp and a diffusing medium such as opal or frosted glass, close to the projection lens. The light is then sent backwards through the optical system of the projector. A small spot of light will be formed on a piece of paper held at the focal point of the rear condenser lens. The size of this spot indicates the maximum light source size the projector can utilize. Obviously, the more filament we can crowd into this useful source area, the higher will be the screen illumination. That answers the question as to why higher wattage lamps are not used for motion picture projection. The higher wattage involves more filament; it simply cannot be crowded into the useful source area. The 30 volt, 30 ampere filament works out as the one which enables us to put the maximum amount of tungsten in this area, without involving other difficulties, such as very high current seals, the use of ribbon filament, etc.

It is interesting to note that the light from the Mazda lamp is steady and of a pleasing color value in that range of the spectrum to which the eye is most sensitive. Tests have shown that lower illumination from Mazda lamps will give just as satisfactory pictures as considerably higher intensities from arc lamps.

The Mazda lamp, therefore, offers the following advantages:

For The Theatre Manager

Lower cost and better projection (a saving of about $300 per year over equivalent arc).

For The Projectionist

A noiseless light source, emitting no fumes, giving off a minimum of heat, and easy to operate, resulting in more healthful and comfortable operating conditions.

For The Theatre Patrons

A steady picture of a color value to which the eye is most accustomed, and, therefore, pictures that are neither tiring nor trying for the audience.

For The Dealer

Good profits more than offsetting any resultant loss in arc lamp business.

Projection Lamps

Naturally the Mazda lamps that are used in projection work are made in various sizes to go with certain classes of projectors. The following table shows this classification:

Class of Service	*Type of Projector*	*Width of Picture*	*Throw*	*MAZDA Lamp*
Motion Picture Theatre	Standard Theatre	16 ft. 14 ft.	120 ft. 100 ft.	30 V. 900 W. T-20 30 V. 600 W. T-20
Schools, Churches, Auditoriums	Semi-portable or Suit-case Type	10 ft. 8 ft. 8 ft.	80 ft. 70 ft. 60 ft.	30 V. 900 W. T-20 30 V. 600 W. T-20 115 V. 1000 W. T-20
	Stereopticon	14 ft. 12 ft. 8 ft.	100 ft. 75 ft. 40 ft.	115 V. 1000 W. T-20 115 V. 500 W. T-20 115 V. 250 W. T-20
	Portable Motion Picture (35 mm. film)	8 ft.	50 ft.	115 V. 500 W. T-20
	Portable Motion Picture (16 mm. film) Opaque Projector	4 ft. 4 ft.	20 ft. 20 ft.	50 V. 200 W. T-10 115 V. 1000 W. T-20
Home and Office Use	Portable Motion Picture Projector (16 mm. film) Steropticon and Opaque Projector Postcard Projector	4 ft. 3 ft. 6 ft. 2 ft.	20 ft. 20 ft. 20 ft. 10 ft.	50 V. 200 W. T-10 115 V. 100 W. T-8½ 115 V. 500 W. T-20 115 V. 60 W. A-21
Advertising Projector	Stereopticon	12 ft. 10 ft.	75 ft. 60 ft.	115 V. 1000 W. T-20 115 V. 500 W. T-20
	Film Projector	8 ft. 6 ft.	60 ft. 50 ft.	115 V. 1000 W. T-20 115 V. 500 W. T-20

Coiled Coil Filament Lamps

The smaller types of projectors, in order to gain compactness, often use the smaller size film, small condensers, etc. The practice of using small parts generally results in an optical system which will utilize only a small size filament. As the 110 volt filaments were not sufficiently concentrated, lamps with lower voltage filaments were designed and used, the line voltage being cut down by rheo-

stats or transformers. Recent developments in the art have evolved a method of concentrating the 110 volt filaments more than was previously possible. The coiled filament has been recoiled, and the mounted filament is consequently more concentrated than before. This has been made possible by special treatments of the wire to prevent it from sagging.

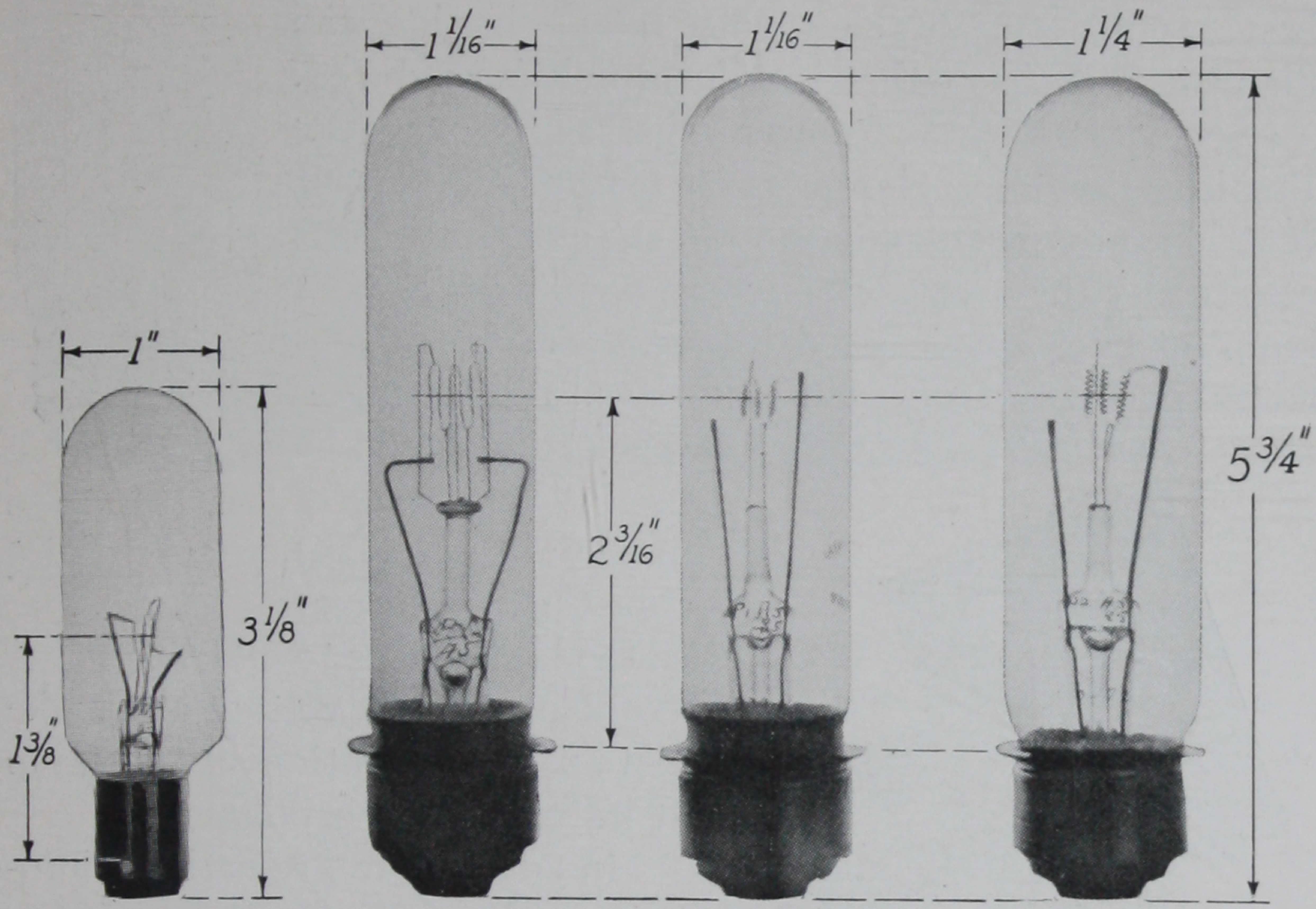


FIG. 27. The decided gain in filament concentration made possible by use of the coiled coil filament is at once evident upon comparing the relative sizes of the coiled filament, second from the left, and the coiled coil filament of the other two projection lamps, at the right. On the 100 and 200 watt lamps, the prefocused base is shown, which is used with the sockets illustrated in Fig. 38.

It is proposed to have a line of coiled coil projection lamps. The 50 watt, 100 watt, and 200 watt, 115 volt lamps are now available. Equipment should, whenever possible, be designed to accommodate the 200 watt lamp in order that sufficient illumination on the screen may be assured. As the voltage reducing device is eliminated, smaller and lighter weight machines are possible.

Some of these lamps are shown in Fig. 27, in comparison with the single coil projection lamps. It is believed that this is a very important step forward in the manufacture of projection lamps.

Projection Microscopes

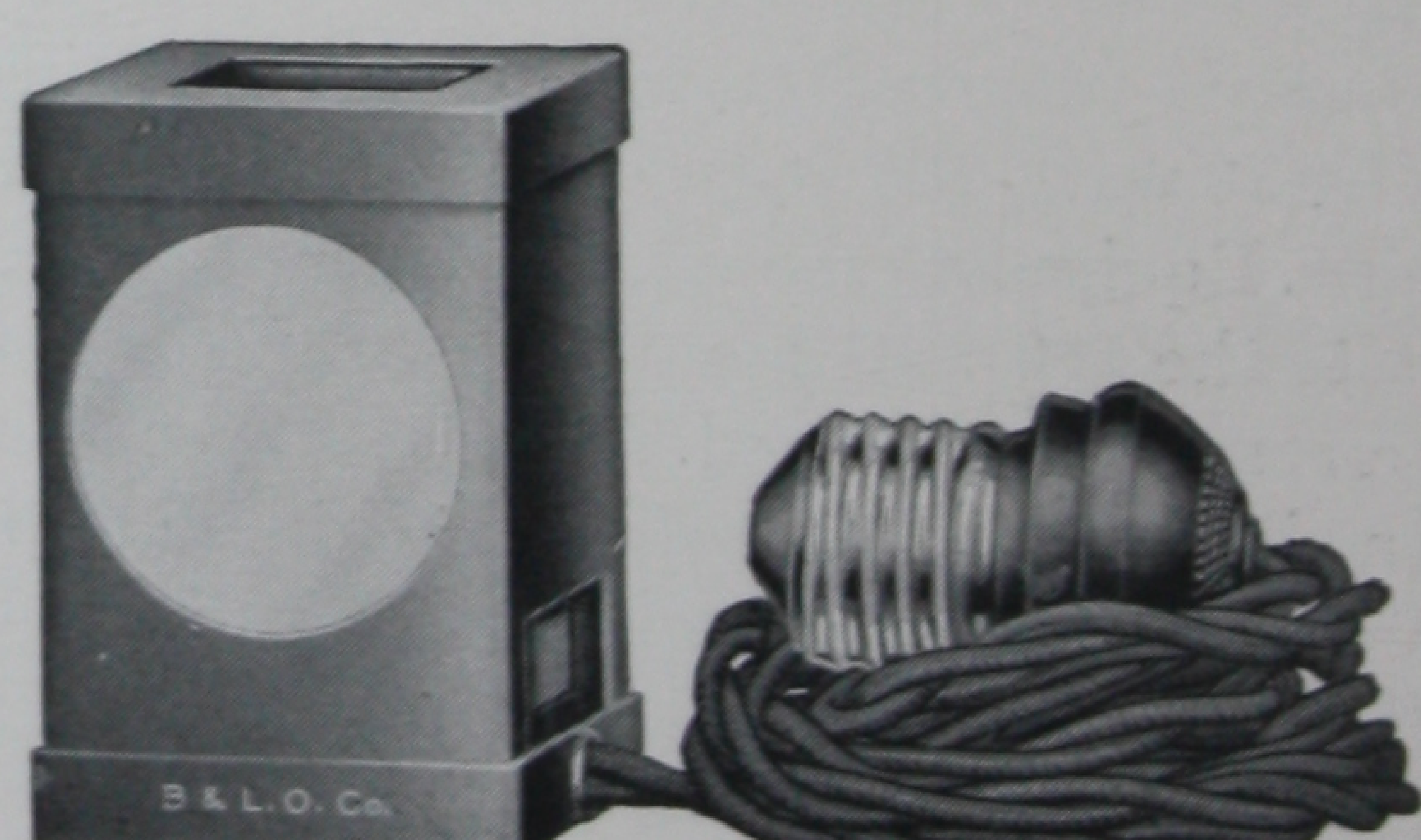
There is another form of projector that plays a very big role in the scientific and educational field, namely, the projection microscope. When extremely high magnification is used and the image is to be photographed, it is essential to have a steady light. For this class of service, it has been found that best results are obtained with lamps having the filament so designed that a uniform field is produced.

FIG. 28. Lamp for microscopic service.

Some of the lower power microscopes used the English Pointolite lamp quite successfully, but that has now been replaced almost entirely in this country by the 6 volt, 18 ampere, T-10 bulb MAZDA lamp for microscopic service (Fig. 28). This is generally operated from a transformer. When this is done, care should be used to have leads of ample size (No. 10) from the transformer to the lamp, so as to avoid any drop in voltage and make certain the operation of the lamp at its maximum brilliancy.

In addition to projection microscopes, there are ordinary microscopes, for which lamp houses are provided, so as to illuminate the object under observation. Fig. 29 shows typical outfits of this character and Fig. 30 shows one of these lamps in use.

FIG. 29. The microscopist in his work often finds need for concentrated illumination upon the object under observation. Lamp houses of the types shown above and at the right are used for this service, their location with respect to the microscope being shown in Fig. 30.



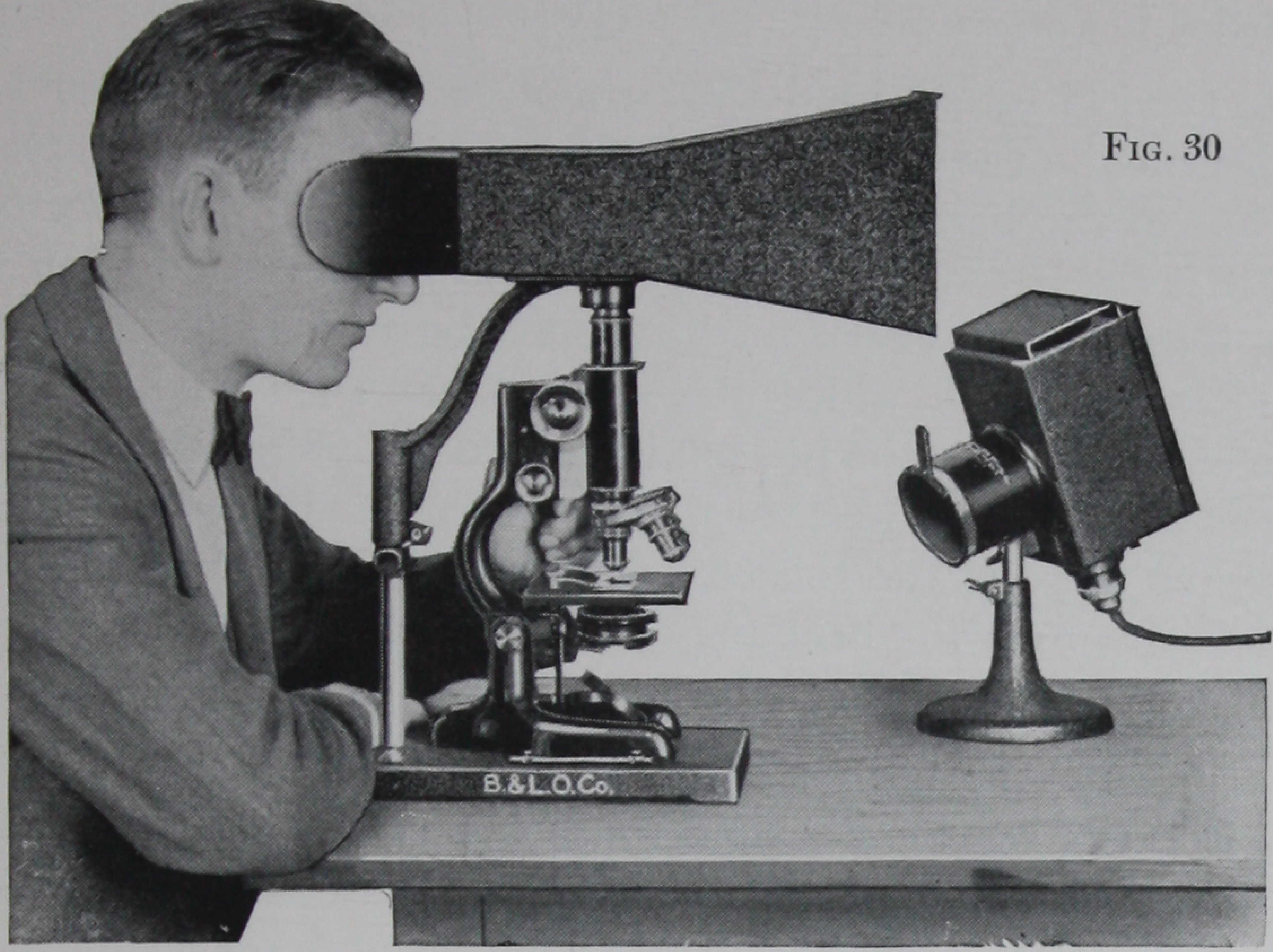
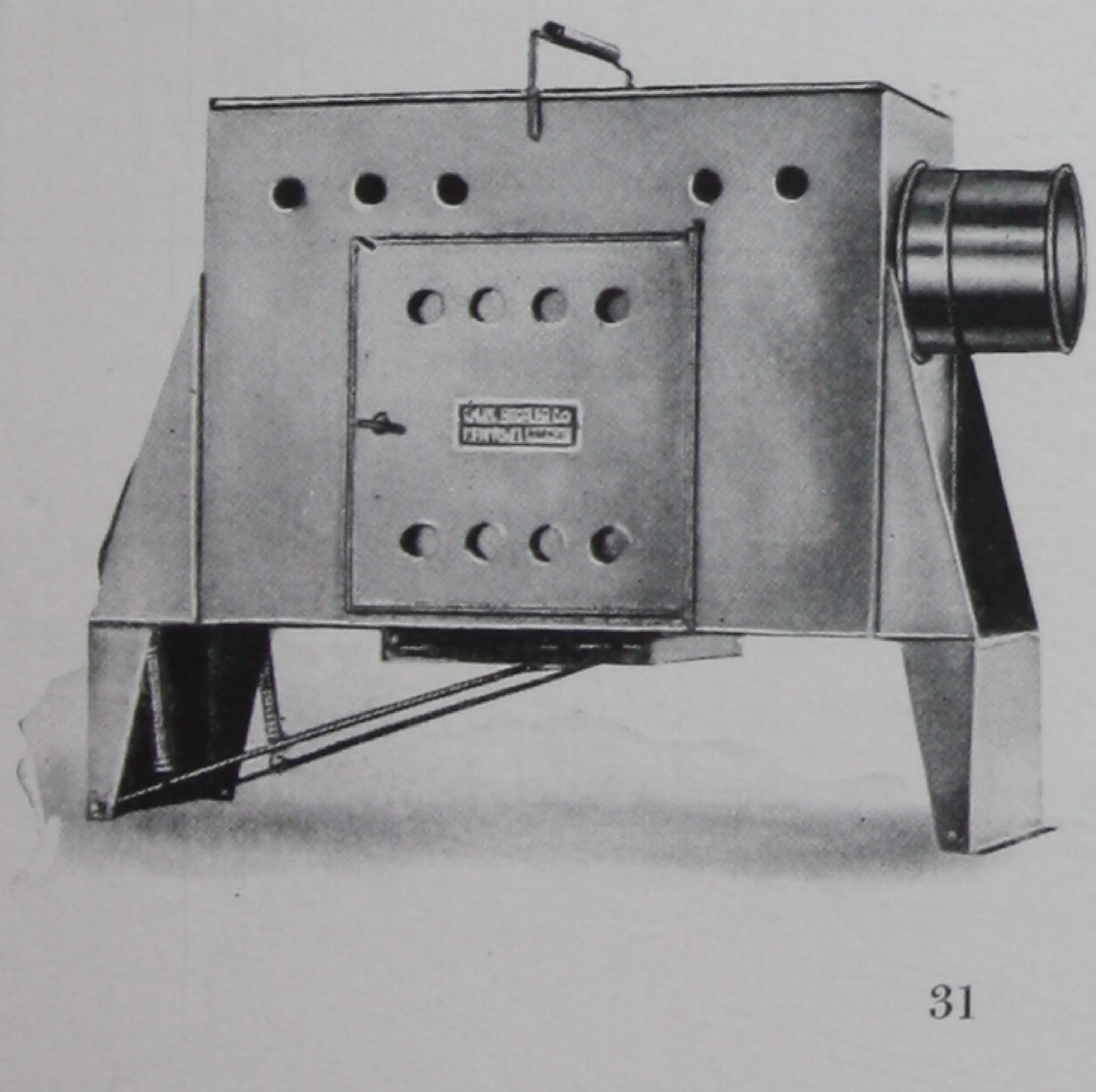


FIG. 30

Postcard Projectors

Passing from the utilitarian field to the toy field, we find MAZDA lamps used for projection purposes in toy motion picture machines and postcard projectors. The former are low priced duplicates of the larger projectors and usually take 100 watt concentrated filament lamps. The postcard projector, however, does not require a concentrated filament lamp. It needs a flood of light evenly distributed over the card; for this purpose two of the 60 watt, 115 volt, A-21 bulb, inside frosted lamps give good results. Fig. 31 shows the optical train of a postcard projector and a typical projector.



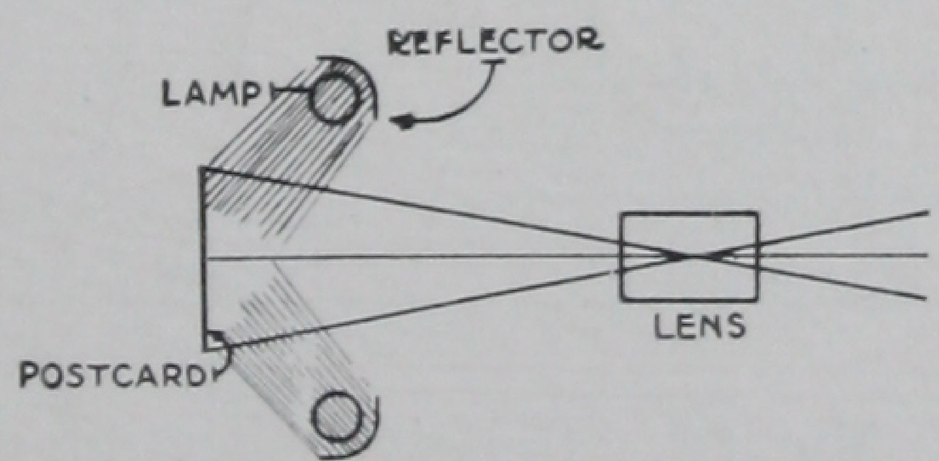


FIG. 31. One design of the popular postcard projector is shown at the left; and above, a diagram of the optical system.

Screens

The type of screen used with a motion picture projector has a great bearing on the effectiveness of the picture. We see the picture by means of the light reflected to our eyes from the surface on to which it is projected. If this, therefore, is to be viewed from wide angles, its reflection characteristics must be such as to give a wide distribution. A plain white plaster wall has such characteristics. On the other hand, if the picture is viewed over a relatively narrow angle, as in a long narrow theatre, a screen should be chosen that will confine most of the reflected light within this angle, and thus materially increase the brilliancy of the picture (Fig. 32).

A most complete study of the reflection characteristics of motion picture screens has been made by L. A. Jones, of the Eastman Kodak Co., and reported in the *Transactions of the Society of Motion Picture Engineers*, Vol. 11, October, 1920. Distribution curves are shown from various surfaces and from the different commercial screens.

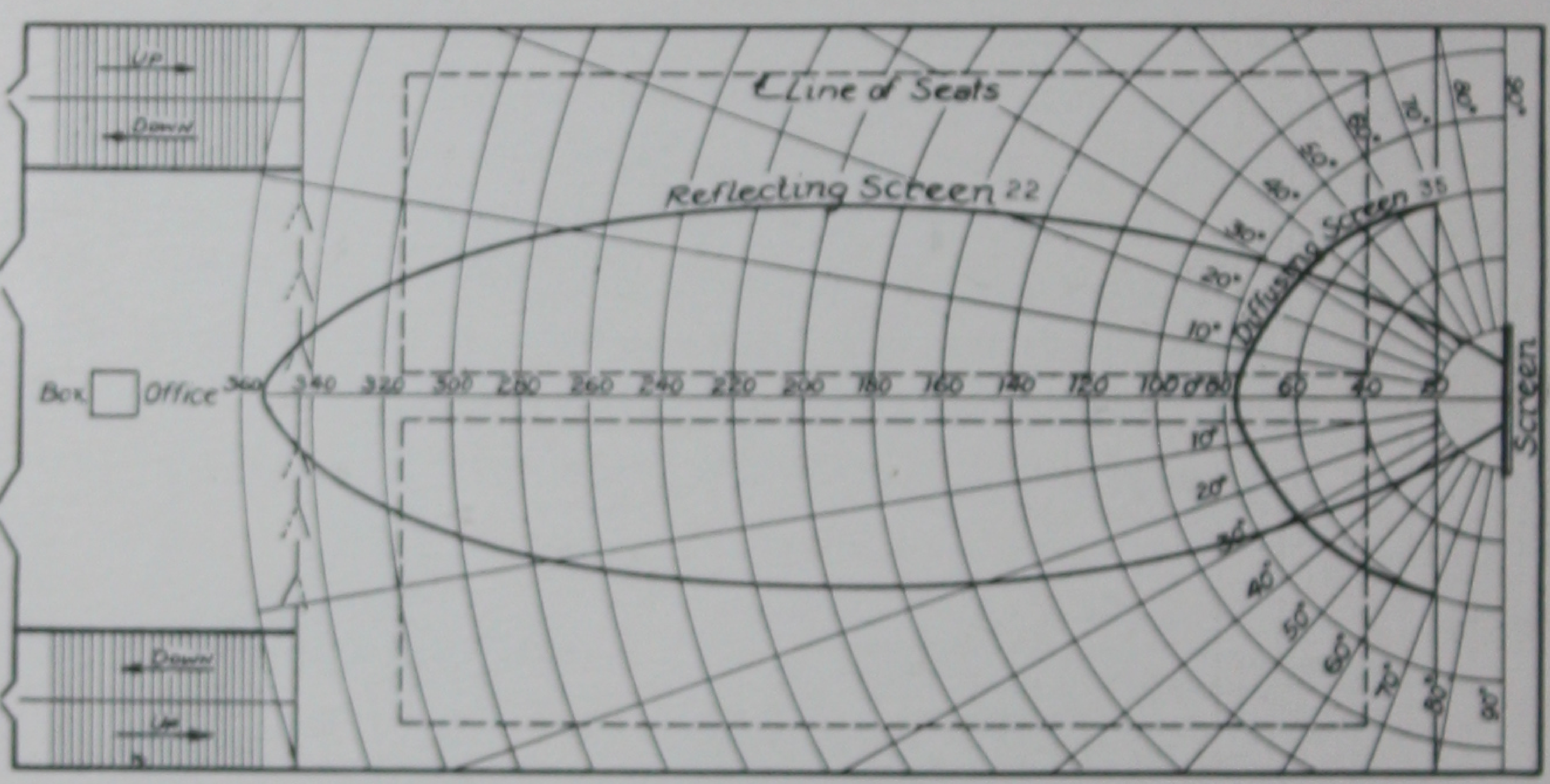


FIG. 32. Relative reflecting characteristics of two extreme types of screens.

A screen should be selected which has high reflection efficiency, so as to make possible the use of the minimum amount of energy to secure a good picture. With this essential satisfied, some consideration should also be given to selecting a screen which will harmonize with its surroundings.

As a quick and ready reference the tables below are taken from the article mentioned above.

Mr. Jones states that the ratio of brightness between the center of the screen and the extreme angle at which it is observed should not exceed 4. He has divided the screens commercially available into three classes as follows:

Class A includes those screens which are adapted for use in theatres where the maximum angle of observation does not exceed 30°; Class B includes the screens adapted for use where the maximum angle of observation does not exceed 40°; while the Class C screens should be used in all cases where the angle of observation is greater than 50°. The point should again be emphasized that these classifications are not rigid, but of an approximate character.

Table 1

No.	*Class*	*Trade Name*	*Texture*	*Color*
10	A	Superlite	Coarse Grain	Metallic White
11	A	Special	Coarse Grain	Metallic White
12	B	Green Back	Fine Grain	Metallic White
13	B	White Back	Fine Grain	Metallic White
14	C	Plain White Coated	Smooth	Yellow
15	A	Imsco Silver No. 1	Coarse Grain	Metallic White
16	A	Imsco Gold No. 1	Coarse Grain	Metallic Yellow
17	A	Imsco No. 2	Coarse Grain	Metallic White
18	A	Imsco No. 3	Medium Grain	Metallic White
19	B	Imsco No. 4	Fine Grain	Metallic White
20	C	Imsco White Muslin	Smooth	White
21	A	Minusa A	Medium Grain	Metallic White
22	A	Minusa B	Coarse Grain	Metallic White
23	A	Minusa C	Coarse Grain	Metallic White
24	A	MAZDA-Lite	Fine Grain	Metallic White
25	B	Idealite—Grade 1A	Fine Grain	Metallic White
26	B	Idealite—Grade 1B	Medium Grain	Metallic White
27	B	Idealite—Grade 2	Fine Grain	Metallic White
28	C	Daylite Crystal White	Smooth	Blue Green
29	B	Daylite Gold Fibre	Fine Grain	Metallic Yellow
30	A	Dalite Silver	Fine Grain	Metallic White
31	A	Argus Crystal Bead No. 1	Medium Glass Beads	Yellow
32	B	Argus Crystal Bead No. 2	Fine Glass Beads	Yellow
33	B	Mirroroid	Fine Grain	Metallic White
34	A	Gold Ring	Smooth	Metallic Yellow
35	C	Half-tone	Smooth	White
36	A	Aluminum Paper	Smooth	Metallic White

Assuming, for each classification, cases in which the maximum angles of observation are 20°, 30°, 40°, and 50°, the values of the ratio of the reflecting power at normal observation to that at these

various angles were computed for all screens, and likewise values of mean reflecting power for the same limiting angles. These values are tabulated for the Class A screens in Table 2, for the Class B screens in Table 3, and for the Class C screens in Table 4.

Table 2

CLASS A

(Adapted for use where maximum angle of observation does not exceed 30°.)

No.	20°		30°		40°		50°	
	$R_0°/R_{20}°$	Reflecting Power	$R_0°/R_{30}°$	Reflecting Power	$R_0°/R_{40}°$	Reflecting Power	$R_0°/R_{50}°$	Reflecting Power
34	2.70	209	5.94	167	10.3	137	16.8	116
31	3.22	159	5.48	127	6.10	108	6.17	96
22	2.38	265	4.96	216	9.92	167	16.3	151
15	2.21	218	4.34	178	8.70	147	13.4	134
21	2.06	253	4.30	207	8.47	172	13.2	145
10	2.23	205	4.14	169	7.82	140	12.3	119
24	2.08	253	4.02	209	8.35	174	13.6	147
23	2.08	245	4.00	201	8.10	167	13.7	141
11	1.80	242	3.20	204	5.75	172	11.3	147
16	1.69	228	3.20	184	6.03	152	9.75	130
36	2.00	112	2.96	96.4	4.34	83.3	5.59	73.2
30	1.70	151	2.82	128	4.35	110	6.36	87
17	1.63	192	2.77	165	4.85	141	7.77	121
18	1.64	172	2.58	150	4.25	128	6.08	112

Table 3

CLASS B

(Adapted for use where maximum angle of observation does not exceed 40°.)

No.	20°		30°		40°		50°	
	$R_0°/R_{20}°$	Reflecting Power	$R_0°/R_{30}°$	Reflecting Power	$R_0°/R_{40}°$	Reflecting Power	$R_0°/R_{50}°$	Reflecting Power
12	1.55	179	2.45	155	3.91	135	6.30	117
19	1.55	161	2.34	141	3.88	129	5.95	109
13	1.45	156	2.06	139	3.34	121	5.37	106
33	1.43	123	1.93	111	2.87	99	3.97	88
26	1.96	151	2.67	131	3.30	115	3.70	104
29	1.39	111	1.83	100	2.68	90	3.68	79
25	1.59	130	2.05	115	2.75	104	2.91	94
32	1.78	112	2.30	99	2.56	89	2.76	82
27	1.52	120	1.86	108	2.23	98	2.56	91

Table 4
CLASS C
(Adapted for use where angle of observation is greater than 50°.)

No.	20°		30°		40°		50°	
	$\frac{R_0°}{R_{20}°}$	Reflecting Power	$\frac{R_0°}{R_{30}°}$	Reflecting Power	$\frac{R_0°}{R_{40}°}$	Reflecting Power	$\frac{R_0°}{R_{50}°}$	Reflecting Power
35	1.10	75.3	1.14	73.5	1.20	71.7	1.23	70.4
14	1.05	71.0	1.06	71.0	1.07	70.0	1.07	67.0
20	1.06	64.0	1.09	64.0	1.10	52.0	1.10	54.0
28	1.02	71.0	1.03	70.0	1.04	70.0	1.07	69.0

Method of Using Tables

It is possible from the figures in Tables 2 to 4 inclusive to choose the best screen for any one of the cases considered. For instance, assuming that the maximum angle of observation is 20°, it will be noted that all values in the ratio column are less than 4 (Table 2). Therefore, from the standpoint of distribution, any one of the screens in Class A will be satisfactory for use where the angle of observation does not exceed 20°. In order now to obtain the maximum average brightness within this angle for a minimum current consumption, it is only necessary to choose that screen, or screens, which show the highest value in the column headed "Reflecting Power." Now, assuming a maximum angle of 30°, we find that the first 7 screens are excluded, since the ratio of normal to extreme reflecting power is greater than 4. Beginning with No. 11, we may then choose the screens showing the highest average reflecting power for the range 0° to 30°. When the maximum angle of 40° is considered, we find no screen in Class A which does not exceed the limiting value of 4 for reflecting power ratio. We therefore turn to Table 3, and there find that all values of the reflecting power ratio are less than 4. We may therefore select from Class B that screen which has the highest reflecting power for the 0-40° range. In case of the 50° limiting angle, three of the Class B screens are automatically excluded, and it is only necessary to select from the remainder the one having the highest average reflecting power for the range 0° to 50°.

For certain classes of work, particularly lecture room work, where the speaker also has to operate the projector, translucent screens are very useful (Fig. 33). With such a screen the pictures are projected from behind the screen and show through it. This has the advantage of enabling the lecturer to stand in front of his audience and at the same time operate the projector. This type of screen is also used to considerable extent with automatic advertising projectors.

FIG. 33. The translucent portable screen, on which the picture is projected from the rear, is a convenient accessory for lecture work.

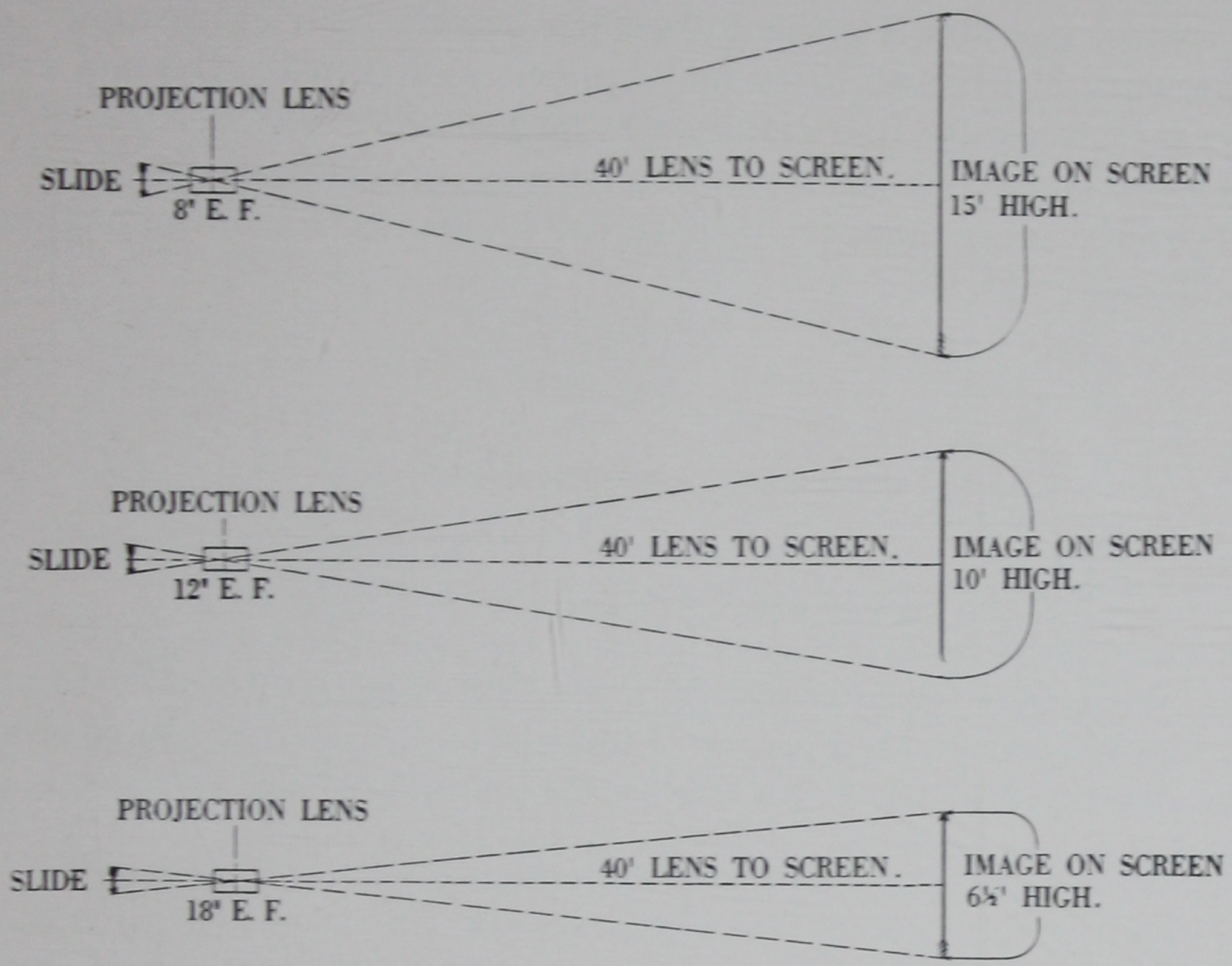
Focal Length of Objective Lens

With either stereopticon or motion picture projectors, the size of pictures shown is controlled by the focal length of the objective or projection lens used.

The various lens and projector manufacturers have available tables which show at once the focal length lens to use when the throw (distance from the projector to the screen) and size of picture desired are known (Fig. 34).

Hints on Operation

There has been prevalent for some time a practice in motion picture laboratories, inspection rooms, etc., which should be changed.



· For Lantern Slides, 2¾ x 3-inch Mat Opening

Focus of Lens in. Inches	Distance from Lantern to Screen												
	15 ft.	20 ft.	25 ft.	30 ft.	35 ft.	40 ft.	45 ft.	50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.
6	7½	10	12½										
8	5½	7½	9½	11¼	13	15							
10	4½	6	7½	9	10½	12	13½						
12	.....	5	6¼	7½	8¾	10	11¼	12½	15				
15	.....	4	5	6	7	8	9	10	12	14	16½		
18	.....	.....	.....	5	5¾	6½	7½	8¼	10	11½	13	15	16½
20	.....	.....	.....	4¼	5	5¾	6½	7¼	8¾	10¼	11¾	13¼	14¾
22	.....	.....	.....	.....	.....	5¼	5¾	6½	8	9¼	10½	12	13¼
24	.....	.....	.....	.....	.....	4¾	5¼	6	7¼	8½	9¾	11	12¼

EXAMPLE—A 10-inch lens used at a distance of 40 feet from the screen will project an image measuring 12 feet on its longer side.

FIG. 34. Table for determining size of picture on screen with lenses of various focal lengths at different throws.

It is not uncommon to inspect films under a screen intensity running all the way from 20 to 40 foot-candles. Prints are made of the proper density to appear to best advantage under this high intensity, and

then they are distributed to theatres where the intensity, on the average, is from 6 to 8 foot-candles. True, the intensities in a few theatres, such as the Capitol and Strand in New York City, run as high as 25 foot-candles at the screen; but that is far above the average. If a film is printed of proper density for viewing under an intensity of from 20 to 40 foot-candles, and then is exhibited at 6 to 8 foot-candles, the results will be far below the best possible. Screen intensities in inspection rooms, previewing rooms, etc., should be made comparable with the intensities where the pictures will finally be used.

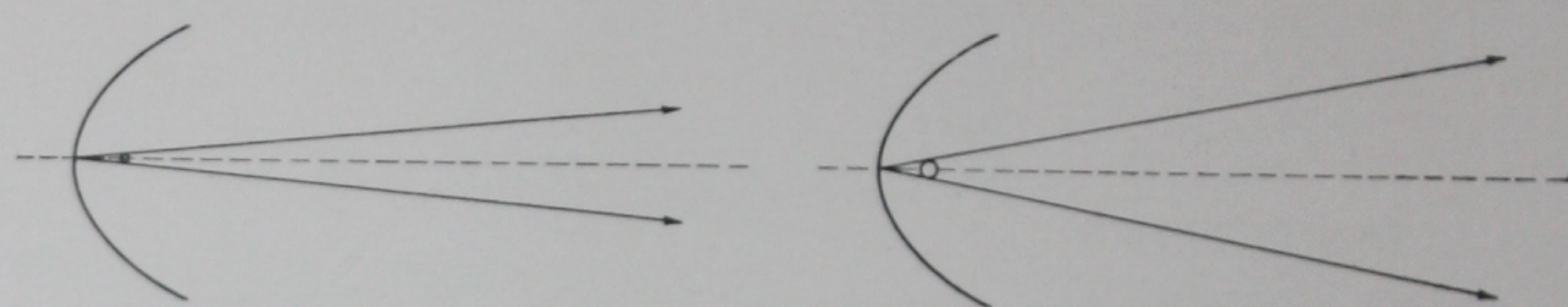


FIG. 35. Effect of size of source upon spread of projected beam.

With most forms of optical projection it is essential first to use a highly concentrated source of light of high brilliancy. In general, we can say that the larger the source the greater will be the spread of the projected beam. This can be seen from Fig. 35.

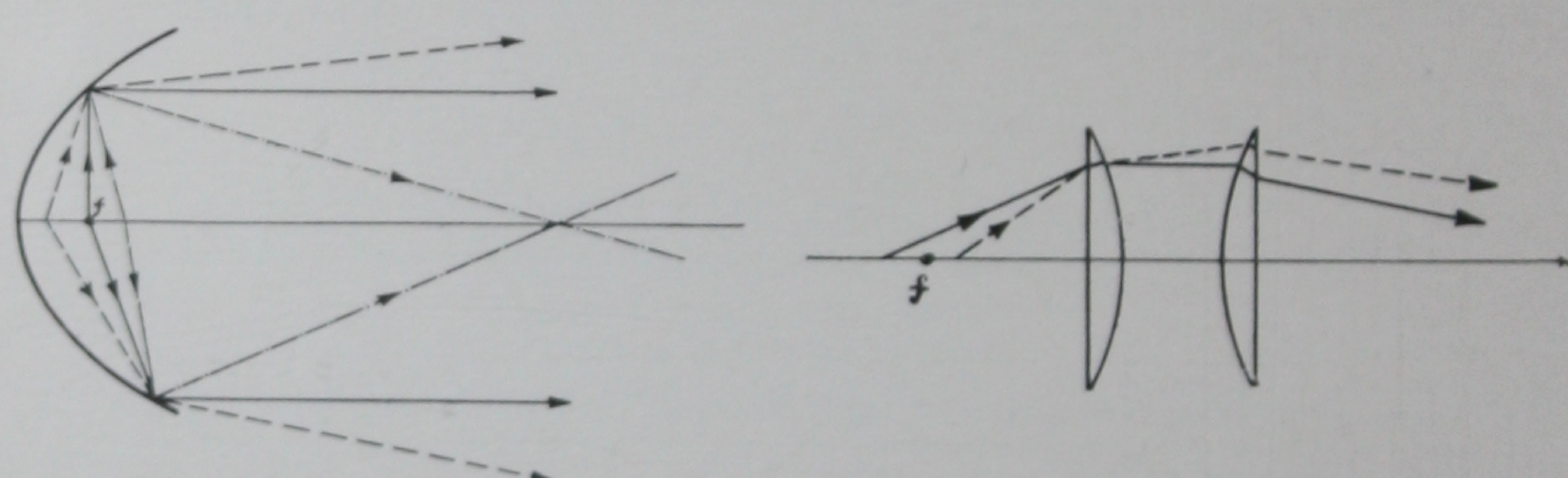


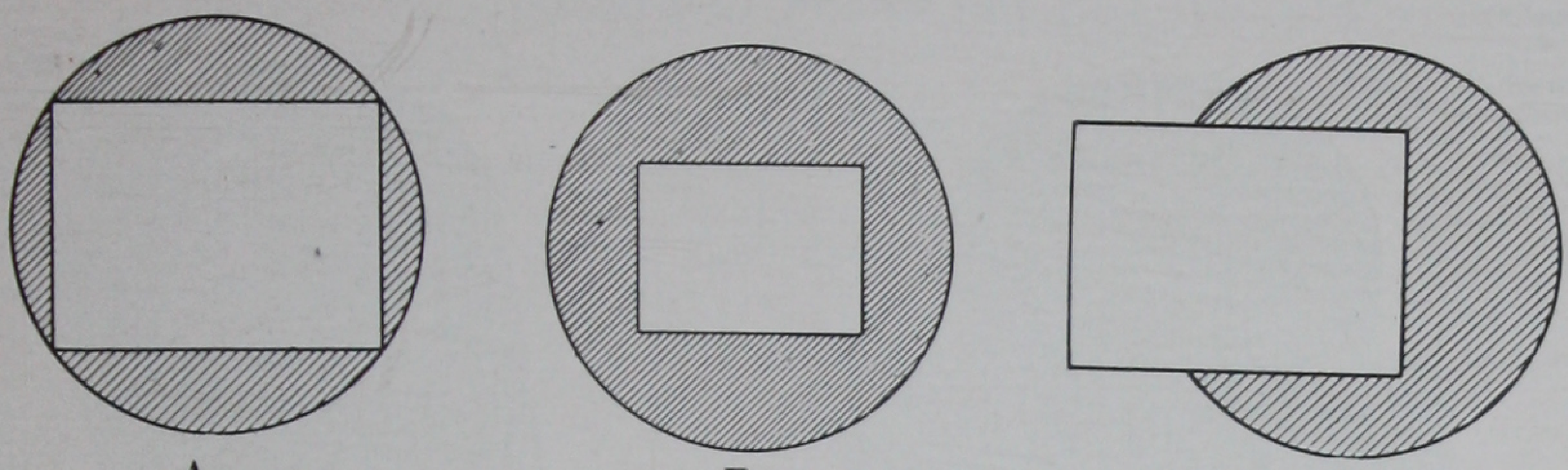
FIG. 36. When the light source is either ahead or behind the focal point of the optical device, the beam will be spread.

Secondly, it is essential that the light source be located accurately at the focal point of the optical device, lens, or reflector. If the source is either ahead or behind the focal point, the projected beam will be spread (Fig. 36).

If it moves too far from the focus along the axis, a dark area will appear in the center of the beam. This may mean a great loss of light. Take the optical system of the motion picture projector, for example. Here it is necessary to pass as much light as possible through the aperture plate—a rectangular opening whose height

is ¾ its width. As the condenser projects a round spot of light into the aperture plate, it is obvious that the maximum light passes through the aperture when the diameter of the spot exactly equals the diagonal of the aperture (Fig. 37A).

The light falling outside the aperture is lost.



A B C

FIG. 37. In the motion picture projector, a round spot of light is projected from the condenser lens upon the aperture plate, which has an opening with a height equal to ¾ of the width. It is clear that the maximum amount of light will be allowed to pass when the diameter of the spot equals the diagonal of the aperture, as shown in A. When the light source is ahead or behind the focal point, and the beam is spread, as shown in Fig. 36, light falling outside the limits of the aperture is wasted (B). Also, when the light source is at the left of the focal point, the beam is projected to the right of the aperture (C); and the converse is also true. In both of these positions, light is wasted.

Obviously if the light source moves away from the focal point, and the beam is spread, the area covered by this wasted light is increased rapidly (Fig. 37B).

If the light source is moved to the right of the focal point, the beam is deflected to the left. If the source goes to the left, the beam goes right. If it goes up, the beam goes down, and vice versa. Any one of these cases also results in a loss of light (Fig. 37C).

It is, therefore, essential that, in any optical device, the light source be located with great care. Detailed instructions regarding the methods of doing this are given in the manufacturer's instruction sheets accompanying various projectors; therefore, they will not be repeated here. In general, however, we advise with any projector (except those equipped with fixed focus lamps and sockets), moving the light source around and observing the resultant screen illumination. Some spot will be found which is quite evidently the best, that is, giving a compromise between uniformity and maximum brilliancy of screen illumination.

The large projector operated by a trained teacher or projectionist is generally focused accurately. On the other hand, the small projector for home use is seldom accurately adjusted. To secure

maximum illumination under these conditions, there has been developed a prefocused type of lamp base and socket. By means of this, each lamp is adjusted optically in the laboratory, so that when installed in the projector, the filament will come at exactly the correct position in the lens system. The prefocused base is illustrated in Fig. 27, and the socket in Fig. 38.

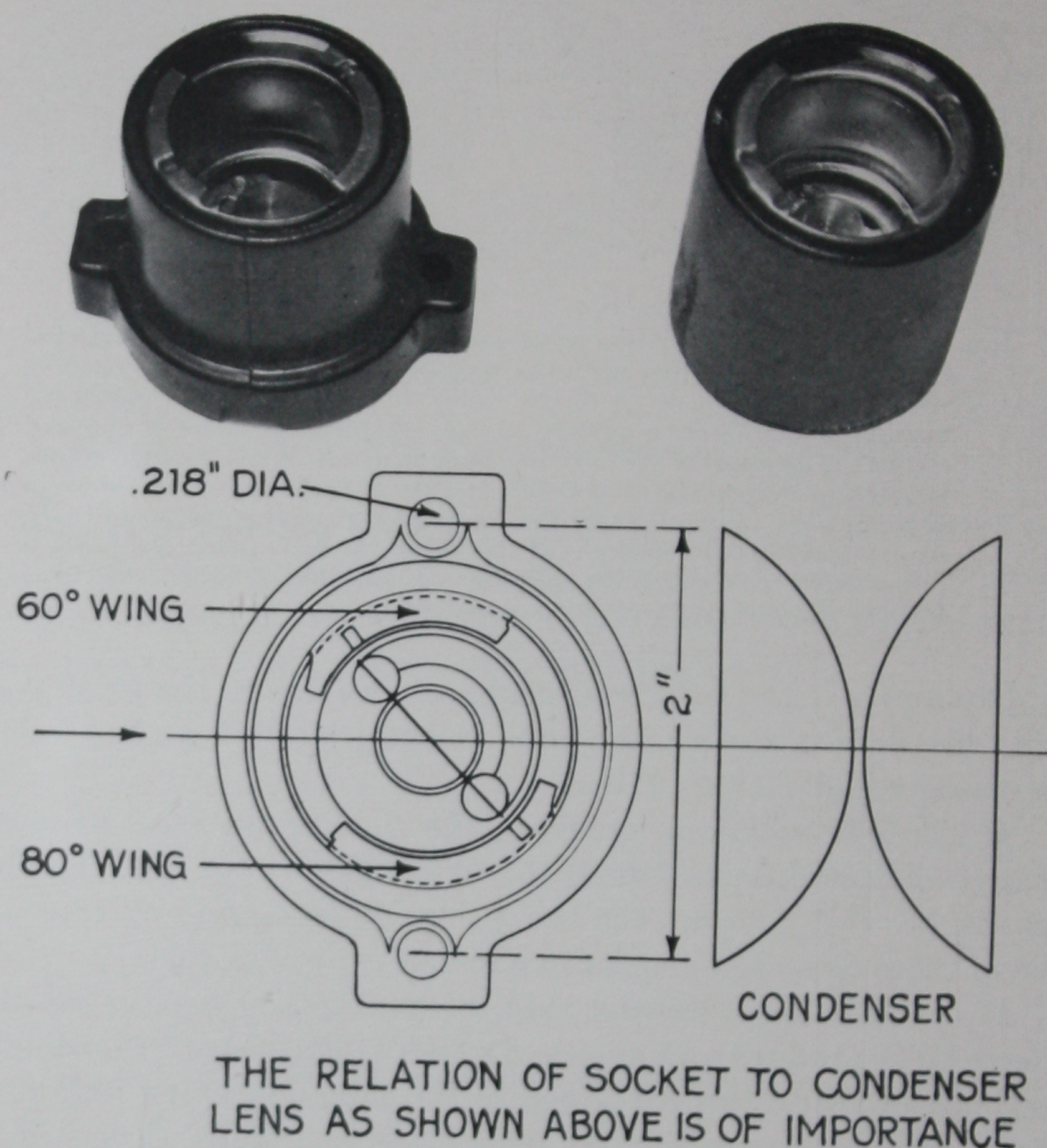


Fig. 38. With lamps equipped with the prefocused base, shown in Fig. 27, it is possible to make adjustments at the time of manufacture so that, when the lamp is placed in the prefocused socket (two forms of which are shown above), the filament will be at the right location in the optical system. Insertion of the lamp in the socket is restricted to the correct position by the dissimilar wings shown in the plan.

In order to continue to obtain the best screen results, lamps that are becoming blackened should be replaced by new ones. Always be sure to use the correct voltage lamps, and, in the case of low voltage lamps, adjust the rheostat to maintain the correct current through the lamp.

Proper Lamps for Commercial Projectors

Listed below are a few of the types of stereopticons and small projectors, with the proper lamp to use in each device:

AUTOMATIC ADVERTISER, INC. . . . . Projector
200 W. 115 V. T-10 bulb, C-13 filament, prefocused base.

BAUSCH & LOMB OPTICAL CO. . . . . Balopticons
Model KRMS—400 W. 115 V. G-30 bulb, C-5 filament, medium screw base.
Model BB—400 W. 115 V. G-30 bulb, C-5 filament, medium screw base.
Model B—400 W. 115 V. G-30 bulb, C-5 filament, medium screw base.
Model BC—600 W. 115 V. T-20 bulb, C-13 filament, mogul screw base.
Model HRM—400 W. 115 V. G-30 bulb, C-5 filament, medium screw base.
Model JCRM—400 W. 115 V. G-30 bulb, C-5 filament, medium screw base.
Model CRM—1000 W. 115 V. T-20 bulb, C-13 filament, mogul screw base.
Model A—400 W. 115 V. G-30 bulb, C-5 filament, medium screw base.
Model CL—1000 W. 115 V. T-20 bulb, C-13 filament, mogul screw base.

BELL & HOWELL CO. . . . . Film Projector
200 W. 50 V. T-10 bulb, C-13 filament, medium screw base with focusing ring.

CHAS. BESELER CO. . . . . Stereopticons
Model B—1000 W. 115 V. T-20 bulb, C-13 filament, mogul screw base.
Science Teacher Model E—600 W. 115 V. T-20 bulb, C-13 filament, mogul screw base.
Uneek Lantern—400 W. 115 V. G-30 bulb, C-5 filament, medium screw base.
Stereomotorgraph Model W—400 W. 115 V. G-30 bulb, C-4 filament, med. screw base.

Brayco Projector, Distributed by ANSCO PHOTO PRODUCTS, INC.
MAZDA No. 1142 lamp, 12-16 V. 21 CP. S-11 bulb, double contact base.

A. S. CAMPBELL CO. . . . . Cello Projector
200 W. 50 V. T-10 bulb, C-13 filament, medium screw base.

CAPITAL MACHINE CO. . . . . Projector
500 W. 115 V. T-20 bulb, C-13 filament, medium screw base.

DEVRY CORPORATION . . . . Projector
500 W. 100 V. T-20 bulb, C-13 filament, medium screw base.

DUPLEX MOTION PICTURE INDUSTRIES, INC. . . . . Projector
200 W. 115 V. T-10 bulb, C-13 filament, medium screw base.

EASTMAN KODAK CO. . . . . Projectors
Model A Kodascope—200 W. 50 V. T-10 bulb, C-13 filament, medium screw base.
Model C. Kodascope—100 W. 115 V. T-8½ bulb, CC-13 filament, prefocused base.

E. LEITZ, INC. . . . . Projector
200 W. 115 V. T-10 bulb, C-13 filament, medium screw base.

PATHEX INC.
20 V. ½ Ampere, T-5 bulb, C-2 filament, special base lamp.

SPENCER LENS CO. . . . . *Delineascopes*
Models E, F, and H—500 W. 115 V. T-20 bulb, C-13 filament, mogul screw base.
Model I—200 W. 115 V. T-10 bulb, C-13 filament, prefocused base.
Model J—1000 W. 115 V. T-20 bulb, C-13 filament, mogul screw base.
Model L (Automatic)—200 W. 115 V. T-10 bulb, C-13 filament, prefocused base.
Model N—500 W. 115 V. T-20 bulb, C-13 filament, mogul screw base.
Models P and R—1000 W. 115 V. G-40 bulb, mogul screw base.

TRANSLUX DAYLIGHT PICTURE SCREEN, INC.......................Projector
500 W. 120 V. T-20 bulb, C-13 filament, mogul screw base.
1000 W. 120 V. T-20 bulb, C-13 filament, mogul screw base.

WYKO PROJECTOR CORP.
250 W. 115 V. T-14 bulb, C-13 filament, medium screw base.

In conclusion, the authors wish to acknowledge their indebtedness to the following concerns for assistance in compiling this bulletin, and for the liberal use of data and cuts taken from their catalogues:

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Chas. Beseler Co. . . . . New York, N. Y.
Eastman Kodak Co. . . . . Rochester, N. Y.
Bell & Howell Co. . . . . Chicago, Ill.
Wyko Projector Corp. . . . . New York, N. Y.
Pathex Inc. . . . . Jersey City, N. J.
Herbert & Huesgen . . . . New York, N.Y.
and all others with whom we have been in touch in this connection.

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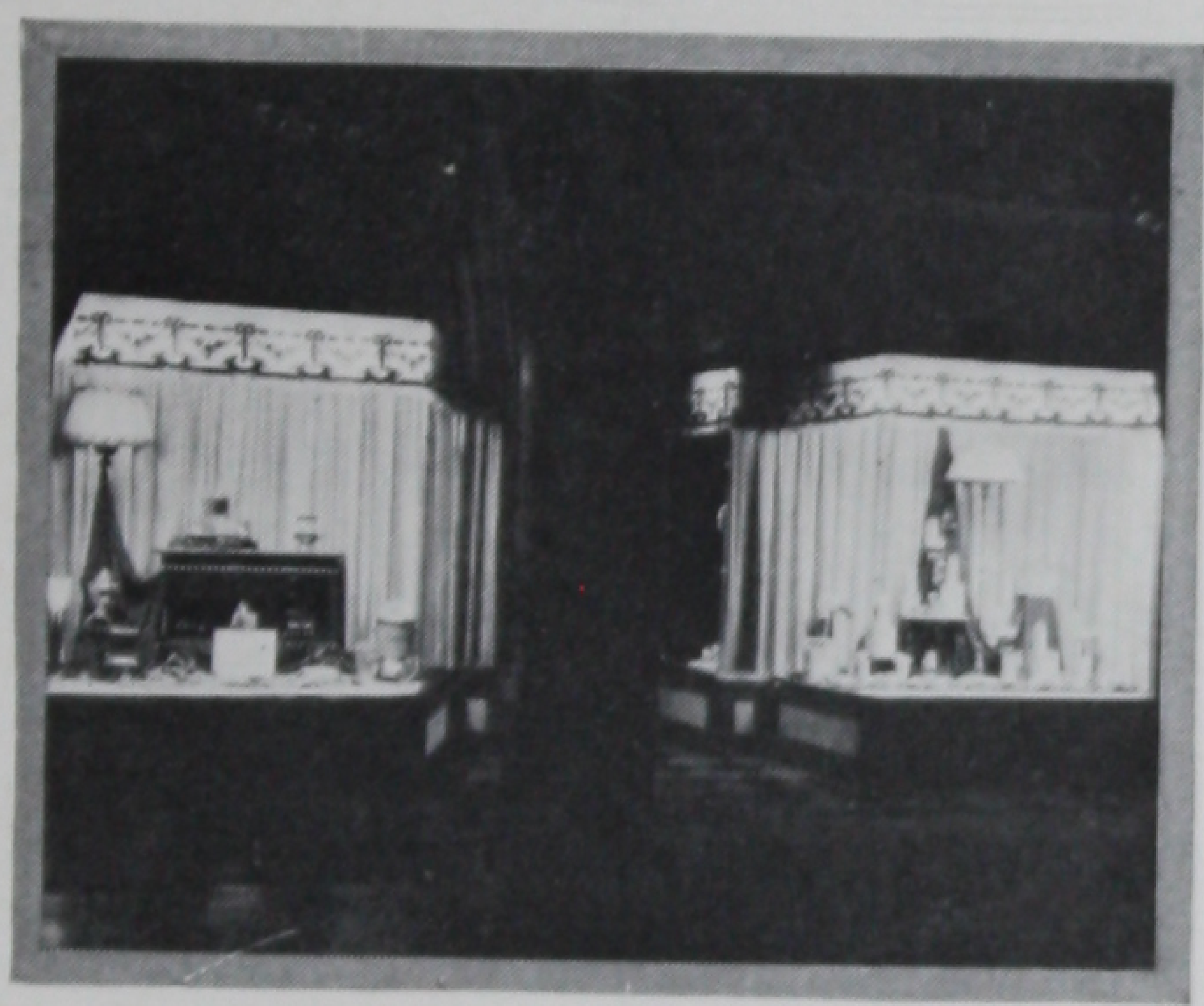

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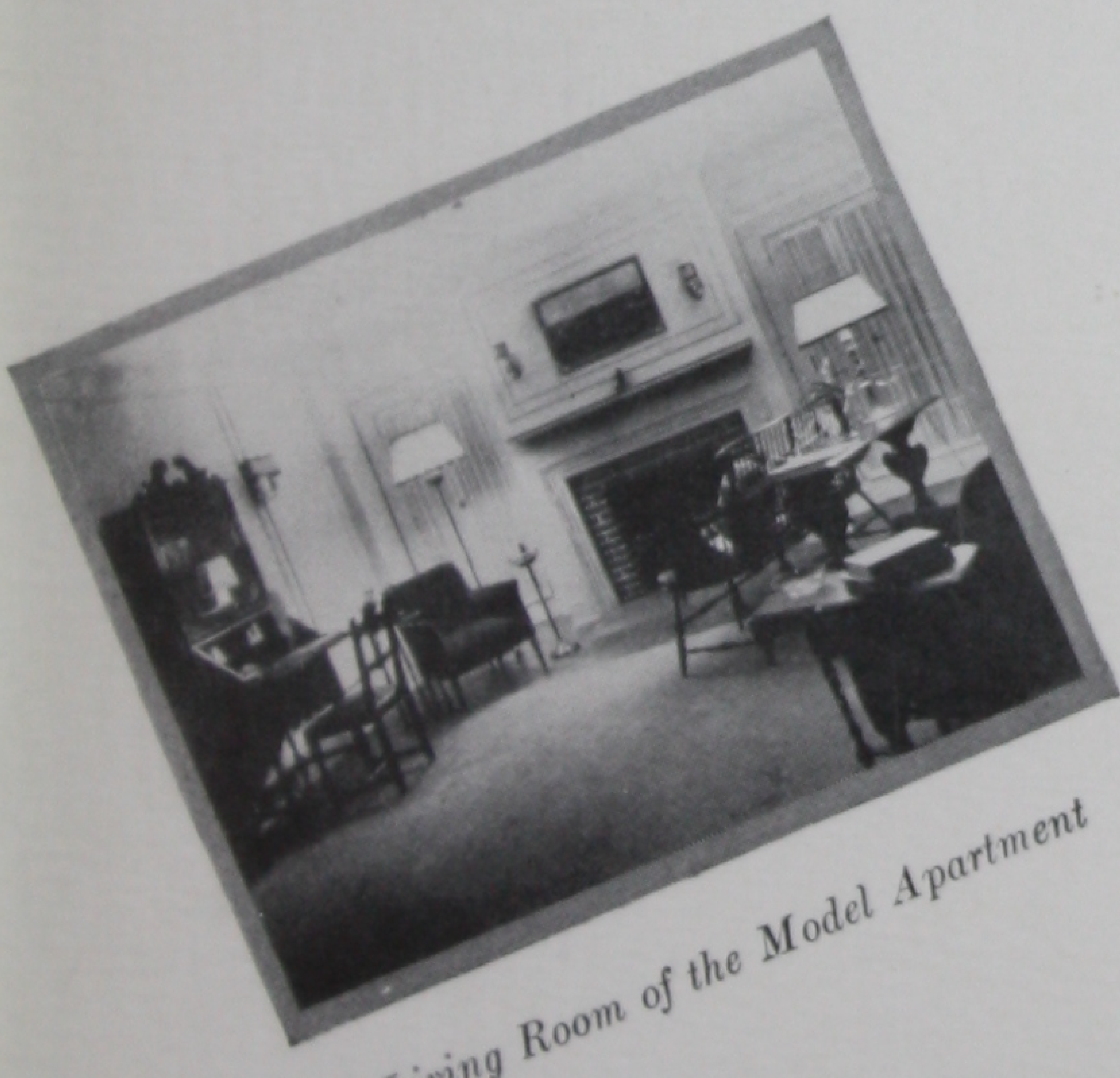

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